PRAGUE AGN SEMINAR SERIES
February – May 2022
pragueagn.wordpress.com/seminars

Astronomical Institute of the Czech Academy of Sciences

14th February
13:00 CET

- ***Relic Nuclear Star Clusters and their hidden Super-Massive Black Holes***
- Presenter: **Karina Voggel**
- Affiliation: Université de Strasbourg, France
- Relevant paper: Voggel *et al.*, (2022; A&A-658A-152)
- ***Abstract:***

I will summarize the current state of the field of surviving nuclear star clusters and what the future holds for these objects with the advent of large surveys such as Euclid. These former Nuclear Star Clusters (NSCs) end up in the halos of massive galaxies when they are stripped of their surrounding stars by tidal forces. Many of these former nuclei contain "hidden" SMBHs, a signpost of their past in the centers of a large galaxy. I will show how can can identify surviving nuclei and use them to trace galaxy and SMBH formation.
I will in particular show NGC7727, a system that has two potential nuclear star clusters, one in the photometric center of the galaxy and one offset by only 500pc. Using high-resolution MUSE data, we detect a SMBH in each Nucleus, confirming that the offset nucleus is the relic of a galaxy that has merged with NGC7727. This is the first dynamically confirmed dual SMBH system at a separation of less than a kpc. The orbital parameters of the SMBHs show that it is in an advanced state of merging and it will constitute a ∼1:25 mass ratio SMBH merger and produce a gravitational wave event. The discovery of this offset SMBH is another confirmation that many SMBHs exist outside the centers of galaxies that have not been discovered yet but are a crucial element for our understanding of black holes as well as galaxy assembly.

Astronomical Institute
of the Czech Academy
of Sciences

21st March
13:00 CET

– ***Do Radio Active Galactic Nuclei Reflect X-ray Binary Spectral States?***
– Presenter: **Emily Moravec**
– Affiliation: Green Bank Observatory, USA
– Relevant paper: Moravec *et al.*, (2022; arXiv-220211116)
– ***Abstract:***

Over recent years there has been mounting evidence that accreting supermassive black holes in active galactic nuclei (AGNs) and stellar mass black holes have similar observational signatures. Further, there have been investigations into whether or not AGNs have spectral states similar to those of X-ray binaries (XRBs) and what parallels can be drawn between the two using a hardness-intensity diagram (HID). To address whether AGN jets might be related to accretion states as in XRBs, I will present the results of recently published work where we explore whether populations of radio AGNs classified according to their (a) radio jet morphology, Fanaroff-Riley classes I and II, (b) excitation class, high- and low- excitation radio galaxies, and (c) radio jet linear extent, compact to giant, occupy different and distinct regions of the AGN HID.

PRAGUE AGN SEMINAR SERIES
February – May 2022
pragueagn.wordpress.com/seminars

Astronomical Institute of the Czech Academy of Sciences

4th April
13:00 CEST

- ***A spectral model of accretion ejection: the JED-SAD model applied to X-ray binaries and AGN***
- Presenter: **Samuel Barnier**
- Affiliation: Université Grenoble Alpes, France
- ***Abstract:***

I will present the JED-SAD model, a spectral model stemming from self-similar magnetized accretion ejection solutions around black holes. In the JED-SAD model, the inner region is an inner Jet Emitting Disk (JED, Ferreira 1997), playing the role of the hot corona, and the outer region is a Standard Accretion Disk (SAD, Shakura & Sunyaev 1973). The JED-SAD can explain both the spectral evolution of the disk and dynamical evolution from the jet observed during X-ray binaries outbursts. I built spectral tables of the JED-SAD model and will present their application to both X-ray binaries observations and the non-linear correlation between the UV and Xray observed in AGN samples.

Astronomical Institute
of the Czech Academy
of Sciences

11th April
13:00 CEST

- ***Measuring black hole mass and the expansion rate of the Universe with X-ray reverberation mapping***
- Presenter: **Adam Ingram**
- Affiliation: Newcastle University, UK
- Relevant paper: Ingram *et al.*, (2022; MNRAS-509-619)
- ***Abstract:***

Stellar-mass black holes accreting gas from a binary partner (X-ray binaries) and supermassive black holes accreting gas from their host galaxy (active galactic nuclei, AGN) can emit a huge X-ray flux from the vicinity of the black hole event horizon. This can be exploited to probe the strong field regime of General Relativity and measure the properties of the black hole: its mass and angular momentum. For all but two objects in the Universe, the vicinity of the accreting BH is far too small to directly image, necessitating the use of mapping techniques that exploit rapid X-ray variability. I will talk about X-ray reverberation mapping, which utilises the relativistically broadened iron emission line that results from centrally emitted X-rays reflecting from the disk. Modelling the light-crossing delay between reflected and directly observed X-rays returns a black hole mass measurement. I will summarise our efforts to measure the mass of stellar and supermassive black holes with our X-ray reverberation mapping code RELTRANS, including our first proof-of-principle constraint on Cygnus X-1. I will then describe how we can use RELTRANS for an even more ambitious goal: measuring the Hubble constant, H0. This is possible because the shape of the reflection spectrum depends on the intensity of illuminating flux, meaning that modelling with RELTRANS can effectively turn bright nearby AGN into standard candles. New, independent methods to measure H0 are currently highly desirable because modelling of the cosmic microwave background returns an H0 value in >4 sigma tension with the value derived from the traditional distance ladder. I will show that the statistical precision required to prefer one of these two discrepant values is achievable with a sample of ∼25 AGN. I will discuss the improvements to our model that are required to achieve such a measurement in reality.

19th May
13:00 CEST

- ***Comparing radio-loud Swift/BAT AGN with their radio-quiet counterparts***
- Presenter: **Maitrayee Gupta**
- Affiliation: Institut de Recherche en Astrophysique et Planétologie (IRAP), France
- Relevant paper: Gupta *et al.*, (2020; MNRAS-492-315)
- ***Abstract:***

Some AGN are known to be efficient producers of strong, relativistic jets that power extended radio sources. Most spectacular with respect to power and size 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 question of why it is so remains unanswered. Since relativistic jets are most likely powered by rotating BHs via the Blandford-Znajek mechanism, one might expect that the parameters key to determining efficient jet production would be 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 RL AGN than in RQ AGN. One might speculate that this difference comes from RL AGN having X-ray contributions 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 quasi-isotropic in both RQ and RL AGN. Hence, we argue that the production of hard X-rays in the RL AGN is like that 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.

– ***X-raying the winds of massive stars using high mass X-ray binaries***
– Presenter: **Victoria Grinberg**
– Affiliation: European Space Agency, ESTEC, the Netherlands
– ***Abstract:***

9th June
13:00 CEST

We are made of stardust—or, at least in significant parts, of material processed in stars. Hot, massive giant stars can drive the chemical evolution of galaxies and trigger and quench star formation through their strong winds and their final demise as supernovae. Yet optical and X-ray measurements of the wind mass loss strongly disagree and can only be reconciled if the winds are highly structured, with colder, dense clumps embedded in a tenuous hot gas. In (quasi-)single stars, however, wind properties are inferred for the whole wind ensemble only; no measurements of individual clumps or clump groups are possible, limiting our understanding of wind properties. Luckily, nature provides us with perfect laboratories to study clumpy winds: high mass X-ray binaries. The radiation from close to the compact object is quasi-point like and effectively X-rays the wind, in particular the clumps crossing our line of sight.

In this talk, I will show how we can use a variety of observations of some of the brightest X-ray binaries to constrain wind properties. Low resolution, high cadence observations combined with simulations reveal the dynamics of clump movements and the large-scale wind structure. Time- and absorption-resolved high resolution X-ray spectroscopy reveals the composition of the multicomponent wind plasma, the layered temperature profile and comet-like structure of clumps. Future X-ray telescopes such as XRISM and Athena will revolutionise the field, allowing us to observe individual clumps in bright sources and, for the first time, make faint sources accessible for high resolution spectroscopy. This will provide us with a sample of HMXBs that will allow us to compare wind properties in massive stars of different stellar (sub-)types and at different radii, thereby directly testing theories of clumpy wind formation and evolution.

Astronomical Institute
of the Czech Academy
of Sciences

13th June
13:00 CEST

- ***Accretion and outflows in stellar-mass black holes***
- Presenter: **Teo Muñoz-Darias**
- Affiliations:
  Instituto de Astrofísica de Canarias (IAC), Spain
  Universidad de La Laguna (ULL), Spain
- ***Abstract:***

Black-hole (BH) transients are a type of X-ray binary in which a stellar-mass BH accretes material from a low-mass star via an accretion disc. They spend most part of their lives in a dim, quiescent state, but display powerful outbursts when their luminosity increases by up to seven orders of magnitude in all wavelengths.

X-ray and radio observations performed during the last couple of decades have provided a rich data base on BH transients. A strong coupling between the properties of the accretion flow and the presence of outflows, such as radio-jets and hot X-ray winds, has been found to be a fundamental characteristic of these systems, and, to a great extend, of X-ray binaries in general. In addition to this, and particularly since the spectacular case of the 2015 outburst of the BH transient V404 Cygni, cold (optical/infrared) accretion disc winds have been discovered in several systems, with observables indicating that they also have a significant impact on the entire BH accretion process.

I will review the state-of-the-art of this field, with emphasis on the studies that we are currently carrying out on these novel cold winds with a suite of the largest telescopes.

Astronomical Institute
of the Czech Academy
of Sciences

16th June
13:00 CEST

- ***X-ray binary accretion states in AGN? Sensing the accretion disc of supermassive black holes with mid-IR nebular lines***
- Presenter: **Juan Antonio Fernández-Ontiveros**
- Affiliation: Centro de Estudios de Física del Cosmos de Aragón (CEFCA)
- Relevant paper: Fernández-Ontiveros, & Muñoz-Darias, (2021; MNRAS-504-5726)
- ***Abstract:***

Accretion states, which are universally observed in stellar-mass black holes in X-ray binaries, are also anticipated in active galactic nuclei (AGN). This is the case at low luminosities, when the jet-corona coupling dominates the energy output in both populations. Previous attempts to extend this framework to a wider AGN population have been extremely challenging due to heavy hydrogen absorption of the accretion disc continuum and starlight contamination from the host galaxies. The luminosity-excitation diagram (LED), based on the [OIV]25.9μm and [NeII]12.8μm mid-IR nebular line fluxes, enables to probe the accretion disc contribution to the ionising continuum. When applied to a sample of 167 nearby AGN, the LED recovers the characteristic q-shaped morphology outlined by individual X-ray binaries during a typical accretion episode, allowing us to tentatively identify the main accretion states in supermassive black holes. The soft state would include broad-line Seyferts and about half of the Seyfert 2 population, showing highly excited gas and radio-quiet cores consistent with disc-dominated nuclei. The hard state mostly includes low-luminosity AGN ($<10^{-3}$ Ledd) characterised by low-excitation radio-loud nuclei and a negligible disc contribution. The remaining half of Seyfert 2 nuclei and the bright LINERs show low excitation at high accretion luminosities, and could be identified with the bright-hard and intermediate states. The hosts of hard-state AGN are mostly passive galaxies, whereas intermediate-state AGN exhibit substantial star formation activity in their central kiloparsecs. I will discuss the above scenario, its potential links with the galaxy evolution picture, and the possible presence of accretion state transitions in AGN, as suggested by the growing population of changing-look quasars.