CPB meeting 2022

Black-hole activity feedback from Bondi-radius to galaxy-cluster scales

Meeting Booklet

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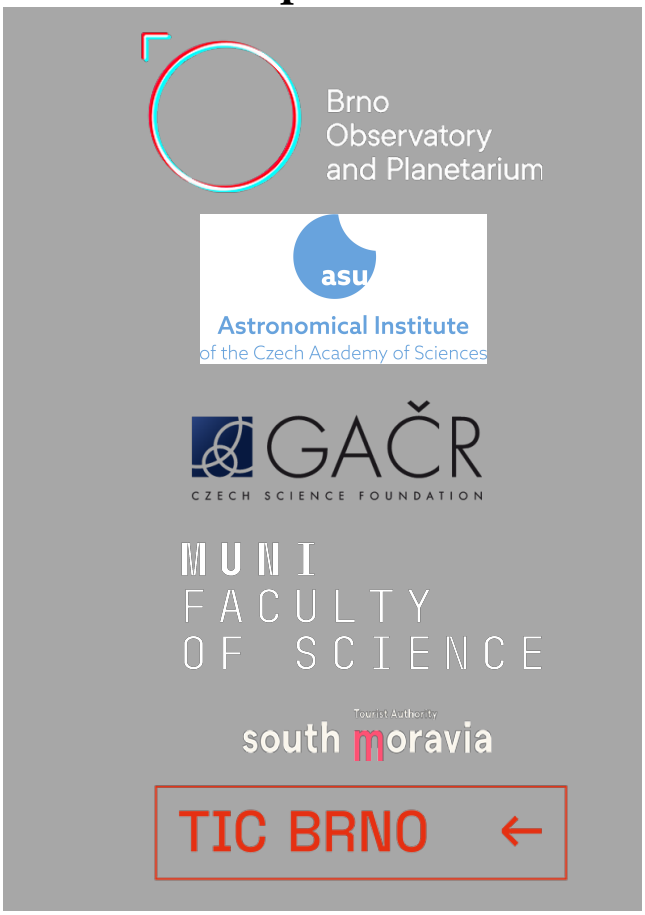

Contents

CONTENTS

Foreword – Nine years of astrophysical meetings between Cologne and Prague

Ahoj!

It is really a big pleasure for me to welcome everyone in Brno, the second largest city in the Czech Republic ($\sim$ 380 000 inhabitants), and the economic and the administrative center of the South Moravian region. During the upcoming three days we will hear about forty talks ranging from the Galactic center all the way to the largest bound dynamical structures in the Universe – galaxy clusters. The program of the meeting will certainly be exciting and enriching for everyone in the audience.

The first Cologne-Prague workshop or at least with the "CP" name was organized in August 2013 in Kiel, hence the name of the workshop was Cologne-Prague-Kiel (CPK) meeting. Quite a few people from the current participant list took part in the first CPK meeting, see the program on this website http://wjd.astrophysik.uni-kiel.de/CPK13/, as well as in subsequent Cologne-Prague meetings that took place alternatively in Prague and Cologne. The previous in-person meeting took place in November 2019 in Schloss Wahn close to Cologne, just shortly before the first cases of COVID-19 appeared. During the COVID lock-down, home-office or "zoom" era, we had one online meeting "Exploring the Universe" in September 2020, which was very enjoyable. However, after nearly two-year home-office mode, we thought it is a high time to organize again a real face-to-face meeting.

After a relatively short discussion, we decided to organize the meeting in Brno, where in July 2021 I started my position in the High-Energy Astrophysics (HEA) group at the Institute of Theoretical Physics and Astrophysics of the Masaryk University. Therefore the meeting name slightly changed to **Cologne-Prague-Brno (CPB)** meeting. Since the focus of the HEA group in Brno is on the physics of galaxy clusters and the intergalactic medium, the CPB meeting will also have two of its sessions dedicated to the physics of the largest bound structures in the Universe.

The common theme of the CPB meeting is the black-hole activity feedback ranging from the smallest scales, i.e. the central parsec in the Galactic center, to active-galactic-nuclei (AGN) hosts (on kpc scales) and even the galaxy clusters, whose dimensions range to several megaparsecs. To better express this connecting topic, we came up with the following CPB meeting title "**Black-hole activity feedback from Bondi-radius to galaxy-cluster scales**". There are some similarities on these scales, i.e. star-formation proceeds in the Galactic center as well as at the galaxy outskirts, similarly galactic nuclei and galaxy clusters contain multiphase medium – warm and hot plasma as well as neutral and molecular gas. But there are also striking differences, i.e. the gravitational potential changes from the point-source dominated to the disk-like potential of the galaxy. In addition, towards the largest scales, the importance of dark matter grows, while it appears to be negligible

for the dynamics in the Galactic center, it is a dominant component in galaxy clusters.

To explore the similarities as well as the differences between the black-hole activity feedback on the smallest and the largest scales, we divided your contributed talks into the following 11 sessions:

1. Galactic Center Session I.
2. Galactic Center Session II.
3. Accretion & GR Session
4. Galactic Center Session III.
5. AGN Feedback & Galaxy Cluster Session I.
6. AGN Feedback & Galaxy Cluster Session II.
7. AGN Session
8. (GR)MHD Simulation Session
9. Galactic Nuclei Temporal & Spectral Properties I.
10. Galactic Nuclei Temporal & Spectral Properties II.
11. AGN vs. quiescent galactic nuclei: Looking for synergies

We are living in really thrilling times of modern astrophysics! It just a couple of weeks since the first resolved image of the Galactic center black hole (though still indirect!) – Sgr A* – was revealed, three years after the image of M87*. In addition, using the exquisite precision of GRAVITY VLTI interferometer, it was possible to confirm the basic predictions of the general relativity (gravitational redshift, Schwarzschild precession) as well as the basic model for Sgr A* flares – the orbiting hot-spot model. Currently, we have ground-breaking instruments available, which have already started to open new "windows" into the Universe, specifically Laser Interferometer Gravitational-wave Observatories (LIGO), Imaging X-ray Polarimetry Explorer (IXPE), and James Webb Space Telescope (JWST). Yet, many crucial questions concerning the Galactic center and the AGN feedback on smaller and larger scales remain still open and waiting for clearer answers. It is our hope as organizers of the CPB meeting that we will hear some proposals to the open problems, and potentially new puzzles will be revealed :)

It is really unfortunate that after more than two years of the COVID-19 pandemic, we are currently facing another major crisis – brutal war in Europe, in Ukraine, which was attacked by the Russian Federation. One of the missiles hit the town Volovets in Zakarpattia Oblast, just about 600 km from Brno. It is also difficult to imagine harsh conditions in the hard-struck city of Mariupol, which is nearly as big as Brno. It should be our aim as researchers to continue doing excellent research and bring about progress, which is even more important in crisis times than in good peaceful times. We stand with Ukraine and Ukrainian researchers, and we also support those Russians and Russian colleagues, who have stood up against this inhuman conflict. In the European history, we have experienced several devastating wars and conflicts and we have learned through a lot of pain and suffering that this is not the way to solve tensions & problems. Similarly, in 1645 citizens of Brno had to defend themselves bravely for three months against the brutal Swedish army led by

general Lennart Torstenson (see the picture below), which was in the end unable to capture the city and had to depart. This way the Moravian and Czech continuity of the city was preserved and Brno is now ready to welcome international visitors from all around the world. We strongly believe that destroyed Ukrainian towns and cities will quickly rise from the ashes and in the not so far future will be able to welcome us, as for instance previously destroyed Cologne and Warsaw frequently do nowadays.

We wish everyone a nice Cologne-Prague-Brno meeting, enjoy the talks, real coffee breaks, and especially have many informal enriching discussions, which will hopefully result in new ideas and research results. We hope you will enjoy Brno, which is smaller than Prague, but still very lively and maybe a bit less spoilt by crowds of tourists :)

Michal Zajaček
on behalf of the CPB Local Organizing Committee

Figure 1: The unsuccessful three-month Swedish siege of Brno in 1645.

Ernst Mach Honorary Medal for Merit in Physical Sciences

Awarded to prof. Dr. Erwin Andreas Eckart
I. Physikalisches Institut, Universität zu Köln, Germany

Ernst Mach Honorary Medal for Merit in Physical Sciences was established by the Czech Academy of Sciences in 1995 and it is named after the world-renowned Austrian physicist and philosopher Ernst Mach, who had roots in the Moravian territory. **Ernst Mach** (1838-1916) was born in 1838 in Chrlice (german *Chirlitz*) close to Brno, which was at that time in the Austrian empire. Chrlice is now in fact a part of Brno (since 1971), hence he can be considered to be a significant figure with a close relation to Brno.

Ernst Mach left a clear and still vivid impact in physics and philosophy, where he represented so-called *neopositivism* or *empirio-criticism*. He contributed to experimental physics, specifically optics, mechanics, and wave dynamics. He and his son Ludwig used the *schlieren* photography for capturing and studying shock waves, and nowadays the unit *Mach* is used to design the ratio between the fluid/object speed and the local sound speed. Furthermore, he also shed light on physiology of senses and perception. In 1867 he accepted the position of chair of experimental physics at the Charles-Ferdinand university in Prague, which he maintained for 28 years. This way he affected significantly Czech physics and can thus be considered to be the "father" of modern Czech physics.

Ernst Mach is also well-known for introducing ***Mach's principle*** in physics, which was also appreciated by Albert Einstein in terms of providing him inspiration while he developed special and general theory of relativity. Broadly speaking, Mach's principle states that the local state of inertia is determined by the large-scale distribution of matter. In some sense, the main aim of the CPB meeting follows this principle: ***we will discuss the processes occurring at small scales in galaxies, in AGN, and connect them with the properties of the largest bound structures in the Universe – galaxy clusters.***

We are meeting in Brno to celebrate progress in science. A part of the CPB meeting is the award ceremony, during which the Ernst Mach Honorary Medal will be awarded to Prof. Erwin Andreas Eckart for his life-long contribution to physical sciences.

The program of the ceremony and the CPB opening banquet is as follows,

17:30-18:00 Arrival of guests, the Ernst Mach Honorary Medal publicly displayed,

18:00-18:05 **Michal Zajaček**, Short welcome speech and introduction

18:05-18:15 **Mgr. Jiří Dušek, PhD.**, Welcome speech of the Brno Observatory and Planetarium director, Ernst Mach and his relation to Brno and Southern Moravia

18:15-18:25 **Prof. Mgr. Tomáš Kašparovský, PhD.** Speech of the dean of the Faculty of Science, Masaryk University

18:25-18:35 **Prof. RNDr. Eva Zažímalová, PhD.** Speech of the president of the Czech Academy of Sciences

18:35-18:45 **prof. RNDr. Vladimír Karas, DrSc.**, *Laudatio* speech (see below)

18:45-18:50 Ernst Mach Honorary Medal handed over to Prof. Dr. Andreas Eckart

18:50-19:20 Award lecture of Prof. Dr. Andreas Eckart in English (30 min)

19:20-19:45 Questions, discussion, and concluding remarks

19:45-21:00 Refreshment and the CPB opening banquet at the planetarium

21:00-21:45 Program in the 3D digitarium: **Stellar circus in 3D**

22:00- Night sky observations in case of a clear sky, or evening discussions on the roof of the planetarium

Laudatio presented on the occasion of the ceremonial presentation of the Ernst Mach medal by the President of the Czech Academy of Sciences, prof. Eva Zažímalová, during the opening of the conference "Black hole activity feedback: from Bondi radius to galaxy-cluster scales", Brno Observatory and Planetarium, 1–3 June 2022.

Professor Andreas Eckart is one of the leading figures in world astronomy and astrophysics. Through his scientific discoveries and university lectures, he has influenced several generations of students who now work in the area of his professional interests at his home University of Cologne, in Max Planck's institutes in Germany, as well as in foreign scientific institutions around the world, including those in the Czech Republic. He was one of the first to develop and use a method to accurately determine the motion of stars in the core of our Galaxy. However, his contribution to the scientific environment is much broader and extends beyond the boundaries of university life and the research field specialization.

Prof. Eckart builds his scientific results on a wide combination of observation methods that cover the entire electromagnetic spectrum from long waves of radio radiation through optical and infrared wavelengths to X-rays. Most famous are his first accurate measurements of the motion of stars in the Milky Way center, which helped confirm the supermassive black hole Sagittarius A* and determine its mass reaching four million masses of the Sun (A. Eckart R. Genzel, "Stellar proper motions in the central 0.1 parsec of the Galaxy", Monthly Notices of the Royal Astronomical Society, volume 284, pp. 576-598, 1997; A. Eckart R. Genzel, "Observations of stellar proper motions near the Galactic Center", Nature, volume 383, pp 415-417, 1996). In addition to a number of scientific articles, he also published the often-quoted monograph The Black Hole at the Center of the Milky Way (A. Eckart, R. Schödel, C. Straubmeier, Imperial College Press, 2005). He stands behind the design and construction of several modern instruments for optical astronomy, which have been developed, for example, for large telescopes of the European Southern Observatory.

Prof. Eckart made innovative measurements of polarization of radiation from the Galactic Center of the near-infrared band (NIR). It is in this area of astrophysics research that the ongoing cooperation with the group of relativistic astrophysics at the Astronomical Institute of the Czech Academy of Sciences began in 2005. Since then, a number of astronomy students took internships in Cologne and Prague; several young people have gone very successfully through both training institutes and they now work as independent researchers. Some of them are present today in this beautiful hall of the Brno Planetarium. It is understandable that in a brief laudatio I cannot mention all the significant deeds of prof. Eckart, but I am very pleased that the appreciation of his work has come now from the Czech academic community and that today we can warmly congratulate the professor for being awarded the Ernst Mach Medal.

prof. RNDr. Vladimír Karas, DrSc.
Astronomical Institute of the ASCR

Figure 2: Ernst Mach Medal of the Czech Academy of Sciences awarded to Andreas Eckart. From the left to the right, Ernst Mach Medal, Andreas Eckart in his Cologne office, the bow shock of IRS 8 in the Galactic center, the supersonic bullet photographically captured by Ernst Mach, and Ernst Mach's portrait.

Chapter 1

Meeting program

1.1 Wednesday (1.6.)

8:00-9:00 **Registration at the Brno Observatory and Planetarium**

9:00-9:15 **Michal Zajaček, Norbert Werner, Vladimír Karas**, Welcome notes

9:15-9:30 **Norbert Werner, Petr Kurfürst**, Introduction to the UTFA and HEA research

Galactic Center Session I. (Chair: Rainer Schödel)

9:30-10:00 **Andreas Eckart**, The Galactic Center : Past and Future

10:00-10:20 **Maria Melamed, Lena Großekathöfer**, L- and K-band analysis of the Galactic center object G1

10:20-10:40 **Florian Peißker**, The turbulent environment of Sgr A*

10:40-11:10 Coffee/Tea break

Galactic Center Session II. (Chair: Rainer Schödel)

11:10-11:30 **S. Elaheh Hosseini**, IRS1W and its mysterious neighboring stars

11:30-11:50 **Harshitha Bhat**, Mid-Infrared studies of dusty sources in the Galactic Center

11:50-12:10 **Michal Zajaček**, AGN feedback on small scales: Depletion of bright red giants in the vicinity of Sgr A*

12:10-12:30 **Petr Kurfürst**, Red giant – jet interaction in galactic nuclei: Hydrodynamical simulations of repetitive stellar passages

12:30-13:30 Lunch break - Monte Bú Restaurant (5 min from the venue)

Accretion & GR Session (Chair: Andreas Eckart)

13:30-13:50 **Vladimír Karas**, The role of spin and charge in black hole astrophysics

13:50-14:10 **Mikolaj Korzyński**, Position drift and redshift drift in general relativity

14:10-14:30 **Jiří Horák**, Eccentric accretion flows: a simple model of the stationary structure and dynamics

14:30-15:00 Coffee/Tea break

Galactic Center Session III. (Chair: Andreas Eckart)

15:00-15:30 **Rainer Schödel**, Formation history of the Nuclear Star Cluster and of the Nuclear Stellar Disc

15:30-15:50 **Álvaro Martínez**, Proper motion studies of the Nuclear Stellar Disc

15:50-16:10 **Nadeen B. Sabha**, VLT/VISIR Mapping of the Galactic Centre: The Central Stellar Cluster

16:10-16:30 **Ladislav Šubr**, Hierarchical four-body dynamics in post-Newtonian regime

16:30-16:35 Short refreshment break

16:35-17:05 **Petr Kurfürst**, *Architecture Gems in Brno*

17:05-17:45 Free time in the planetarium and the surroundings

18:00-∼23:00 Ernst Mach Medal Ceremony at the Planetarium; CPB meeting opening banquet at the planetarium; Program in the 3D digitarium; observations in case of the clear sky

1.2 Thursday (2.6.)

AGN Feedback & Galaxy Cluster Session I. (Chair: Agnieszka Janiuk)

9:00-9:30 **Norbert Werner**, Cosmic bubble-blowers and the baryons that do not form stars

9:30-9:50 **Tomáš Plšek**, The relation between accretion rate, black hole mass, and jet power in massive early-type galaxies

9:50-10:10 **Romana Grossová**, Radio observations of nearby X-ray and optically bright giant elliptical galaxies and their interaction with the intergalactic medium

10:10-10:30 **Anna Wójtowicz**, Radio Loudness of Early-type Galaxies at Low and Very Low Radio Luminosity Range

10:30-11:00 Coffee/Tea break

AGN Feedback & Galaxy Cluster Session II. (Chair: Agnieszka Janiuk)

11:00-11:20 **Carter Rhea**, A New Paradigm in X-ray Spectral Analysis

11:20-11:40 **Jean Paul Breuer**, Exploring the X-ray filamentary structure in Frontier Fields Cluster MACSJ0717.5+3745

11:40-12:00 **Dan Hu**, The Merger Dynamics of Galaxy Cluster Abell 1775 and The Interplay Between the ICM and Two-tailed Radio Galaxies

12:00-12:20 **Orsolya Kovács**, High-redshift AGN through gravitational lensing (online talk)

12:20-12:30 MEETING PHOTO SESSION, inside or outside the planetarium

12:30-13:30 Lunch break - Monte Bú Restaurant

AGN Session (Chair: Vladimír Karas)

13:30-14:00 **Bozena Czerny**, The role of dust in AGN

14:00-14:20 **Vikram Kumas Jaiswal**, Light echo studies of the accretion disk and the broad line region in active galactic nuclei

14:20-14:40 **Munawwar Khanduwala**, Studying the broad line features of Mrk 1018

14:40-15:00 **Persis Misquitta**, An optical view of interacting radio galaxies

15:00-15:20 **Lukas Steiniger**, Nearby Low-Luminosity QSOs and the M-L Relation of Inactive Galaxies

15:20-15:50 *transfer to the Mendel monastery & museum (26 min walk on foot)*

16:00-18:00 Visit of the Augustinian monastery of Saint Thomas in commemoration of Gregor Johann Mendel's 200th birth anniversary

18:30-… CPB-meeting Czech-style Banquet in Pivovarská STAROBRNO

1.3 Friday (3.6.)

MHD Simulation Session (Chair: Bozena Czerny)

9:00-9:30 **Agnieszka Janiuk**, Can MAD accretion disks launching structured jets explain both GRB and AGN engines?

9:30-9:50 **Bestin James**, Modeling the GRB jet properties with 3D general relativistic simulations of magnetically arrested accretion flows

9:50-10:10 **Diego Calderón**, Formation and survival of the observed cold disc around Sgr A*

10:10-10:30 **Petra Suková**, Ultrafast outflows from galactic nuclei: signature of orbiting body?

10:30-11:00 Coffee/Tea break

Galactic Nuclei Temporal & Spectral Properties I. (Chair: Bozena Czerny)

11:00-11:30 **Silke Britzen**, All about jets: precession, variability, and neutrinos (online connection)

11:30-11:50 **Martin Kološ, Arman Tursunov**, Recent breakthrough results on black-hole magnetospheres from Silesia

11:50-12:10 **Matej Kosiba**, A multifrequency characterization of the extragalactic hard X-ray sky

12:10-12:30 **Abhijeet Borkar**, Are the accretion states of AGN and XRBs analogous?

12:30-13:30 Lunch break - Monte Bú Restaurant

Galactic Nuclei Temporal & Spectral Properties II. (Chair: Norbert Werner)

13:30-14:00 **Giorgio Matt**, The Imaging X-ray Polarimetry Explorer (IXPE)

14:00-14:20 **Peter Boorman**, Shining light on the census of supermassive black hole accretion with Nu-LANDS

14:20-14:40 **Kristína Kallová**, Peering through the veil: using hard X-ray spectroscopy to probe the circum-nuclear environment in NGC 3982

14:40-15:00 **Anabella Araudo**, Non-thermal emission and acceleration of UHECRs in AGN jets

15:00-15:30 Coffee/Tea break

AGN vs. quiescent galactic nuclei: Looking for synergies (Chair: Norbert Werner)

15:30-15:50 **Ana Laura Müller**, Non-thermal radiation from disk-cloud interactions in Active Galactic Nuclei

15:50-16:10 **Marcel Štolc**, Interplay between SED and spectral line profiles in the context of gappy accretion discs

16:10-16:40 **Michal Zajaček**, AGN vs. quiescent galactic nuclei: Looking for synergies - *CPB2022 meeting summary*

16:40-17:00 **Andreas Eckart, Vladimír Karas, Norbert Werner, and others**, Closing remarks and open discussion

17:00 - … Free time and sightseeing in Brno, dinner & drinks evening (18:30 - Jean Paul's restaurant; 21:00 - Air Cafe)

Chapter 2

Abstracts

2.1 Galactic Center Session I.

The Galactic Center : Past and Future

Andreas Eckart (University of Cologne & MPIfR)

Abstract: I will highlight some important aspects concerning the research on the Galactic Center. This will include comments on past achievements and future projects making use of upcoming instrumentation like JWST, METIS, EHT etc.

The turbulent environment of Sgr A*

Florian Peißker (University of Cologne)

Abstract: The Galactic center harbors a supermassive black hole called Sgr A*. The presence of such an object does have a major impact on the environment. Surprisingly, the closest stars towards Sgr A* have an estimated young age resulting in the "Paradox of youth". To date, it is not clear how and where the young O/B stars have formed. In this talk, I will present some recent results that have an impact on the star formation history of the nuclear star cluster.

$L-$ and $K-$band analysis of the Galactic center object G1

Maria Melamed & Lena Großekathöfer (University of Cologne)

Abstract: The first observation of G1 in 2004 raised the question about the nature of the object. Initially, it was believed that this object is a heated dust feature in the vicinity of the supermassive black hole Sgr A*. In the following years, observations showed that G1 is moving on a Keplerian orbit bounded to Sgr A* implying a stellar nature. While some authors see evidence for a coreless feature, recent results favor a stellar model. Here we will incorporate K- and L-band data covering almost two decades of IR observations of the Galactic center. We show that the derived properties underline a stellar nature. By following the classification of G2, the Galactic center object G1 can be described as a dust-enshrouded star.

2.2 Galactic Center Session II.

IRS1W and its mysterious neighboring stars

S. Elaheh Hosseini (University of Cologne)

Abstract: We focus on the 28 sources adjacent to the bow shock source IRS1W, located at the distance of 6.05" north-east from the supermassive black hole Sagittarius A*. We present the first proper motion measurements of these sources and we suggest this dense association of stars could be bound by an intermediate mass black hole (IMBH) or it could be explained as a disk-like distribution projected close to the line of sight. We detected 29 stars including IRS1W in H, K_s, L' and partly in M band. We confirm IRS 1W and its adjacent sources are forming a dense association of stars. We speculate about the existence of an IMBH or a disk explanation or the wind effect. Our measurements for the first time reveal that the dense association of stars including IRS1W is a co-moving group of stars at the distance of $6.05''$ north-east from the supermassive black hole Sagittarius A*. The sources in this collection of stars have a similar proper motion and a common nature. This association of stars might be the remnant of a massive stellar cluster that has contained an intermediate mass black hole. The cluster exhibits features similar to IRS13N cluster. We present the proper motion of a group of co-moving stars in the region of IRS1W for the first time.

Mid-Infrared studies of dusty sources in the Galactic Center

Harshitha Bhat (University of Cologne & MPIfR)

Abstract: Mid-Infrared (MIR) images of the Galactic center show extended gas and dust features along with bright IRS sources. Some of these dust features are a part of ionized clumpy streamers orbiting Sgr A*, known as the mini-spiral. We present their proper motions over 12 year time period and report their flux densities in N-band filters. In addition, we derive the spectral indices and temperatures of these sources. The observations were carried out by VISIR at ESO VLT. High-pass filtering led to the detection of several resolved filaments and clumps along the mini-spiral. Each source was fit by a 2-D Gaussian profile to determine the offsets and aperture sizes. We perform aperture photometry to extract fluxes in two different bands. We present the proper motions of the largest consistent set of resolved and reliably determined sources. In addition to stellar orbital motions, we identify a stream-like motion of extended clumps along the mini-spiral. We also detect MIR counterparts of the radio tail components of the IRS7 source. They show a clear kinematical deviation with respect to the star. They likely represent Kelvin-Helmholtz instabilities formed downstream in the shocked stellar wind. We also analyze the shape and the orientation of the extended late-type IRS3 star that is consistent with the ALMA sub-mm detection of the source. Its puffed-up envelope with the radius of $2 \times 10^6\ R_\odot$ could be the result of the red-giant collision with a nuclear jet, which was followed by the tidal prolongation along the orbit.

AGN feedback on small scales: Depletion of bright red giants in the vicinity of Sgr A*

Michal Zajaček (Masaryk University, Brno)

Abstract: In this talk, I will outline our model for the depletion of bright red giants in the Galactic

center during active, Seyfert-like phases of the Sgr A* activity. The model that we presented in the study Zajaček et al. (2020) can potentially connect the Seyfert-like activity of Sgr A* a few million years ago, which could stand behind the Fermi/eROSITA bubbles, and the apparent lack of bright red giants inside ~ 0.5 pc.

Red giant – jet interaction in galactic nuclei: Hydrodynamical simulations of repetitive stellar passages

Petr Kurfürst (Masaryk University, Brno)

Abstract: The lack of red giants in the Galactic center was discovered more than thirty years ago. Several scenarios were proposed to explain the mechanism responsible for depletion of bright red giants: tidal disruption, star-accretion disk or star-star collisions, infall of a massive cluster or a secondary black hole, or dark-matter collisions with red-giant cores. We continue in numerical investigation of recently proposed scenario for bright red-giant outer layers ablation during the stars' passage through the Galactic nuclear jet which was likely active a few million years ago. We calculate in quite realistic details the repetitive star-jet interactions with orbital distance of 0.001, 0.01, and 0.1 pc from the center of our Galaxy. We simplify the red-giant internal structure as a polytropic model of a 1 Solar mass and 100 Solar radii star, while we assume the relativistic jet with velocities equal or above 0.3c and half-opening angle of 10 degrees. The ongoing simulations reveal the rate of the star ablation in dependence of a number of jet crossings and also the impact of these interactions on further evolution of the stars.

2.3 Accretion & GR Session

The role of spin and charge in black hole astrophysics

Vladimír Karas (Astronomical Institute, Czech Academy of Sciences, Prague)

Abstract: Within the framework of General Relativity, "classical" (asymptotically flat) solutions of black holes are fully characterised by their mass, electric charge, and angular momentum. However, once the assumption about asymptotical flatness has been relaxed, the interplay among charge and spin becomes more complicated and less intuitive. Here we discuss the case of black holes embedded in strong magnetic fields of external origin.

Position drift and redshift drift in general relativity

Mikołaj Korzyński (Center for Theoretical Physics, Polish Academy of Sciences, Warsaw)

Abstract: I will present exact expressions for the position drift (or proper motion) and the redshift drift (or the temporal variation of the redshift) for any source and any observer, valid in any spacetime. The expressions take as input the momentary 4-velocities and accelerations of the observer and the source, and the spacetime curvature along the line of sight. They can be used to calculate the drifts for luminous sources in any spacetime, including the vicinity of black holes. I will briefly discuss their possible applications.

Eccentric accretion flows: a simple model of the stationary structure and dynamics

Jiří Horák (Astronomical Institute, Czech Academy of Sciences, Prague)

Abstract: We present a simple semi-analytic model of eccentric accretion flows. We will discuss their radial and vertical structure, as well as properties of the lowest-order oscillation modes.

2.4 Galactic Center Session III.

Formation history of the Nuclear Star Cluster and of the Nuclear Stellar Disc

Rainer Schödel (IAA-CSIC - Instituto de Astrofísica de Andalucía, Granada)

Abstract: The Nuclear Star Cluster has an effective radius of about 5 pc and a mass of about 25 million solar masses. It is the densest stellar system that we can observe in the Universe and contains the massive black hole Sgr A* at its heart. Both Sgr A* and the Nuclear Cluster are embedded in the so-called Nuclear Stellar Disc, a dense, flat stellar system of about 500 pc diameter. I will present recent studies of the structure and formation history of these structures at the Galactic Centre.

Proper motion studies of the Nuclear Stellar Disc

Álvaro Martínez (IAA-CSIC - Instituto de Astrofísica de Andalucía, Granada)

Abstract: The nuclear stellar disc is a dense, flat rotating stellar structure of almost one billion solar masses with kinematics and formation history that clearly distinguish it from the much larger Galactic Bar/Bulge. It has a diameter of roughly 500 pc and coincides with the Central Molecular Zone. In this talk I will present our ongoing proper motion study of this region and show how our data can be used to constrain the line-of-sight distance of molecular clouds and to find so far unknown groups of young stars.

VLT/VISIR Mapping of the Galactic Centre: The Central Stellar Cluster

Nadeen B. Sabha (Institute for Astro- and Particle Physics, University of Innsbruck)

Abstract: The Galactic Centre (GC) is the only galactic nucleus we can observe in detail and the most extreme large-scale astrophysical environment of the Milky Way. It is a GTO target for MIRI/JWST as well as for METIS/ELT. The GC harbours three massive clusters that allow us to study the cluster-based star formation history in this region over the past 8 Myr. I will present and discuss our results from mid-infrared observations of the GC obtained in 2010, 2016, and 2018 with VISIR/VLT. The high-resolution ($\sim$ 0.3") multi-epoch N-band data (at 8.6 μm and 13 μm) cover a large FOV (1 arcmin x 1 arcmin) of the nuclear stellar cluster, the Quintuplet and the Arches cluster, and regions in the Arched Filaments, hence providing the largest maps of these regions taken with ground-based MIR instruments.

Hierarchical four-body dynamics in post-Newtonian regime

Ladislav Šubr (Charles University in Prague)

Abstract: It has been shown that relativistic corrections to the Newtonian dynamics effectively damp oscillations of orbital eccentricity in a hierarchical three-body system. If the lightest body in the classical hierarchical setup is split into two particles on close orbits, their dynamical evolution may be either independent or locked together depending on the parameters of the system. In the latter case, the locked evolution may lead to the faster inspiral of the particles into the central body, reaching large eccentricities in non-negligible number of cases.

2.5 AGN Feedback & Galaxy Cluster Session I.

Cosmic bubble-blowers and the baryons that do not form stars

Norbert Werner (Masaryk University, Brno)

Abstract: Most galaxies comparable to or larger than the mass of the Milky Way host hot, X-ray emitting atmospheres, and many such galaxies are radio sources. Hot atmospheres and radio jets and lobes are the ingredients of radio-mechanical active galactic nucleus (AGN) feedback. While a consensus has emerged that such feedback suppresses cooling of hot cluster atmospheres, less attention has been paid to massive galaxies where similar mechanisms are at play. I will review the results of X-ray and multi-wavelength observations of galactic atmospheres, including their dynamics, development of thermal instabilities, and AGN heating.

The relation between accretion rate, black hole mass, and jet power in massive early-type galaxies

Tomáš Plšek (Masaryk University, Brno)

Abstract: We studied how the presence of thermal instabilities and multi-phase gas affects the relationship between Bondi accretion power and mechanical jet power in 20 nearby early-type galaxies. We found that a strong correlation holds only for galaxies surrounded by thermally unstable atmospheres (Hα+[NII] emission) with cooling time to free-fall time ratio lower than or close to 10. The results indicate that, for thermally unstable galaxies, the cooling atmospheric gas feeds the black holes in the centres of all galaxies at a similar jet-to-Bondi power ratio and assuming the accretion is spherical and Bondi-like, about one per cent of the rest mass of the accreted material is converted into observed jet energy. By separating the Bondi formula into individual components, we also showed that the main source of jet-to-Bondi power correlation is the dependence of jet power on SMBH mass, while thermodynamic properties only have a secondary effect.

Radio observations of nearby X-ray and optically bright giant elliptical galaxies and their interaction with the intergalactic medium

Romana Grossová (Astronomical Institute CAS & Masaryk University, Brno)

Abstract: Many massive early-type galaxies host central radio sources and hot X-ray atmospheres indicating the presence of radio-mechanical active galactic nucleus (AGN) feedback. The duty cycle and detailed physics of the radio-mode AGN feedback is still a matter of debate. To address these questions, we present 1–2 GHz Karl G. Jansky Very Large Array (VLA) radio observations of a sample of the 42 nearest optically and X-ray brightest early-type galaxies. We detect radio emission in 41/42 galaxies. However, the galaxy without a radio source, NGC 499, has recently been detected at lower frequencies by the Low-Frequency Array (LOFAR). Furthermore, 27/42 galaxies in our sample host extended radio structures and 34/42 sources show environmental interactions in the form of X-ray cavities. We find a significant correlation between the radio flux density and the largest linear size of the radio emission and between the radio power and the luminosity of the central X-ray point-source. The central radio spectral indices of the galaxies span a wide range of values, with the majority of the systems having steep spectra and the rest flat spectra. These results are consistent with AGN activity, where the central radio sources are mostly switched on, thus the duty cycle is very high. 7/14 galaxies with point-like radio emission (Fanaroff-Riley Class 0; FR 0) also show X-ray cavities indicating that, despite the lack of extended radio structures at 1–2 GHz, these AGN do launch jets capable of inflating lobes and cavities.

Radio Loudness of Early-type Galaxies at Low and Very Low Radio Luminosity Range

Anna Wójtowicz (Astronomical Observatory of the Jagiellonian University)

Abstract: The radio continuum emission of galaxies is produced predominantly through the synchrotron process, whenever relativistic electrons with sufficiently high energies are present and are accelerated in a strong magnetic field of the system. Such conditions can be found either in star-formation regions of the interstellar medium, or in magnetised plasma outflows launched by supermassive black holes and their accretion disks in galactic nuclei. In the case of the latter, depending on the exact physical conditions and parameters of the central engine (such as accretion rate, black hole spin, magnetization of the accreting matter), the outflows may range from subrelativistic and uncollimated massive winds terminating within host galaxies, to highly relativistic and light but powerful jets reaching extragalactic scales. Here I present preliminary results of our recent studies regarding radio emission of a sample of early-type galaxies, for which the masses of central black holes are measured with high accuracy, and the group/cluster hot gaseous halos are well characterised through X-ray observations. The sample includes about 70 nearby systems, for which neither an exact level of the nuclear activity, nor a presence of relativistic radio-emitting jets, played any role in the selection procedure. The collected 1.4 GHz radio fluxes of the targets (with $\lesssim$ arcmin resolution) span a wide range from 1 mJy for the dimmest source up to 210 Jy for the brightest one. However, the corresponding 1.4 GHz monochromatic luminosities are in fact low and very low, ranging from $L_{\rm R} \sim 10^{41}$ erg/s down to 10^{35} erg/s. For those, we study the correlations with the main parameters of central supermassive black holes, host galaxies, and hot gaseous halos, finding a general bimodality in the radio luminosity distribution, with the borderline value of $L_{\rm R,\,cr} \sim 10^{-9} L_{\rm Edd}$. Sources with radio luminosities below this value, show significantly smaller intrinsic spread in linear regressions of the correlations with black hole masses, galaxy stellar velocity dispersion, or the X-ray halo luminosity, when compared with the sources with $L_{\rm R} > L_{R,\,cr}$. We discuss our findings in the general context of the origin of a radio emission in early-type galaxies

at low and very low luminosity range.

2.6 AGN Feedback & Galaxy Cluster Session II.

A New Paradigm in X-ray Spectral Analysis

Carter Rhea (University of Montreal)

Abstract: X-ray spectral analysis is a powerful tool available to astronomers to study differing astrophysical phenomena from X-ray binaries, galactic black holes, and the intracluster medium. A new *Bayesian paradigm* is emerging in the field of X-ray spectral analysis. However, continued concerns over the choice of priors dominate the conversation. With our new machine learning methodology employing *Mixture Density Networks* (MDN), we use posterior target distributions calculated by an MDN as the priors for a full Bayesian inference approach to X-ray spectroscopy. Additionally, we discuss the potential of deconvolving observed X-ray spectra from the instrumental response using a *Recurrent Inference Machine* (RIM). Our findings indicate that using a RIM to deconvolve the spectrum and then passing the deconvolved spectrum to well-tuned MDN results in inaccurate estimates of the temperature and metallicity values which are critical in the study of galaxy clusters, plasma physics, and feedback astrophysics. In this talk, we will also discuss the implications for use cases and demonstrate the power of this exciting new methodology in our exploration of galaxy clusters.

Exploring the X-ray filamentary structure in Frontier Fields Cluster MACSJ0717.5+3745

Jean Paul Breuer (Masaryk University, Brno)

Abstract: We present the results of Chandra and XMM-Newton X-ray imaging and spatially-resolved spectroscopy of the filament in MACSJ0717.5+3745, an intermediate redshift ($z = 0.5458$) and exceptionally massive ($(3.5 \pm 0.6) \times 10^{15}$ Solar masses) Frontier Fields cluster experiencing multiple mergers. Tight constraints placed on the thermodynamical properties of the filament are acquired using a joint fitting of spectra using nested parameter sampling within a Bayesian framework.

The Merger Dynamics of Galaxy Cluster Abell 1775 and The Interplay Between the ICM and Two-tailed Radio Galaxies

Dan Hu (Masaryk University, Brno)

Abstract: Abell 1775 ($z = 0.0717$) is a nonrelaxed and X-ray luminous galaxy cluster. Meanwhile, the cluster is a rare case that simultaneously contains two-tailed radio galaxies in its central region (< 40 kpc). One of the radio galaxies is identified as a wide-angle tail (WAT) radio galaxy, associated with the brightest cluster galaxy (BCG). However, the origin of another one, a narrow-angle tail (NAT) radio galaxy, is still unclear. More interestingly, LOFAR 140 MHz detection identified a radio mini-halo in the cluster core, implying an ongoing particle reacceleration in the ICM. This talk will introduce the possible merger scenario of Abell 1775 and the interplay between the ICM

and tailed radio galaxies.

High-redshift AGN through gravitational lensing

Orsolya Kovács (Masaryk University, Brno)

Abstract: Although observations of high-redshift quasars demonstrate that many supermassive black holes (BHs) reached large masses within one billion years after the Big Bang, the origin of the first BHs is still a mystery. A promising way to constrain the origin of the first BHs is to explore the average properties of $z \gtrsim 6$ BHs (during the era of reionization), but typical high-redshift BHs remain hidden from X-ray surveys, which is due to their relatively faint nature and the limited sensitivity of X-ray telescopes. Gravitational lensing, however, provides an attractive way to study high-redshift AGN, as it magnifies the faint light from high-redshift sources. In our study, we investigated the X-ray emission originating from 155 gravitationally lensed $z \gtrsim 6$ galaxies utilizing Chandra X-ray observations to constrain the formation scenarios of BHs.

2.7 AGN Session

The role of dust in AGN

Bozena Czerny (Center for Theoretical Physics, PAS, Warsaw)

Abstract: Since many years we know that dust (dusty-molecular torus) is responsible for the obscuration of AGN at large viewing angles and thus for the classification of AGN into type 1 and type 2. Recently, we gain some observational and theoretical insight into geometry of the region and the role of the dust in the dynamics of the outflow and failed winds. I will briefly touch on all these aspects, including the dust-based FRADO model of the formation of the Balmer lines in AGN.

Light echo studies of the accretion disk and the broad line region in active galactic nuclei

Vikram Kumas Jaiswal (Center for Theoretical Physics, PAS, Warsaw)

Abstract: Studying the reprocessing of the incident radiation by the accretion disk in active galaxies is an impeccable tool to study the accretion disk properties. Such light echo measurements (known as continuum reverberation mapping) provide the spatial resolution of micro-arcseconds, which is impossible to achieve by any existing telescope. Ionizing photons from the corona are reprocessed into UV/optical light by the accretion disk. The variability of the ionizing source is mimicked in the reprocessed components but with a delay. This delay is caused by the light travel time to reach the different parts of the accretion disk. Simple relation between the time delay at two optical bands and the absolute monochromatic luminosity of the disk was presented by Collier et al. (1999) as an attractive tool to measure the Hubble constant. However, the method still did not lead to promising results. I will review the previous efforts to model the disk response and the current status of the research. I will present our research based on artificial stochastic light curves for the primary source of radiation, and I will address the issue of how contribution from the Broad Line Region (BLR) affects the results. The delay from a combination of the two reprocessors is rather

sensitive to assumptions about the intrinsic variability of the primary source, the relative disk and BLR flux, and the geometry of the BLR. The final objective of this project is to disentangle the true accretion disk time delay from the total (disk + BLR) signal, since then the disk delay is applicable for cosmology.

Studying the broad line features of Mrk 1018

Munawwar Khanduwala (University of Cologne)

Abstract: The changing-look AGN Mrk 1018 changed its optical type from 1.9 to 1 in 1984. Recently, Mrk 1018 changed back to type 1.9, which was accompanied by its dimming. The source reached the minimum in 2016, which was followed by a period of rebrightening and a low-level variability or flickering. At the same time, the outburst was accompanied by the appearance of the red-wing asymmetry in its broad-line region. This implies a certain degree of inhomogeneity in the broad-line region (BLR) geometry. I will summarize the main properties of the BLR of Mrk 1018 and its time variability.

An optical view of interacting radio galaxies

Persis Misquitta (University of Cologne)

Abstract: In the talk, I will present optical spectra of nine pairs of interacting galaxies that have been selected from an SDSS-FIRST sample. Using optical diagnostic diagrams using low-ionisation emission-line ratios, we see that all of the galactic nuclei associated with radio emission at 1.4 GHz and 4.85 GHz fall in the composite region. The only exception to this is the galaxy in the pair that might not have had a first passage yet. The spectral slope, $\alpha_{1.4/4.85}$, of all of the radio galaxies is $\geq$ -0.7, implying that all of the spectral slopes are either flat or inverted. Additionally, all of the radio galaxies host SMBHs of mass in the range $10^7 - 10^8 \mathrm{M}_\odot$, which is the typical BH mass for quasars. All of the radio galaxies have Eddington ratio, $\log \eta$ in the range [-4,-2]. With the exception of H011, which has a high flux density, all the other flat spectrum galaxies show a steepening in their spectral slope, along with a decrease in the ionisation ratio, with increasing radio loudness.

Nearby Low-Luminosity QSOs and the M-L Relation of Inactive Galaxies

Lukas Steiniger (University of Cologne)

Abstract: Inactive galaxies appear to follow a relation in the Black Hole mass - bulge luminosity diagram, while it is still not clear whether the same relation holds true for active galaxies. A sample of nearby low-luminosity type-1 quasi-stellar objects (LLQSO sample) bridges the gap between local Seyfert galaxies and more distant quasars. We find that this sample does not follow the suggested relation and aim to find the reason for the deviation.

2.8 (GR)MHD Simulation Session

Can MAD accretion disks launching structured jets explain both GRB and AGN engines?

Agnieszka Janiuk (Center for Theoretical Physics, PAS, Warsaw)

Abstract: The structured jets are postulated to account for emission properties of high energy sources across the mass scale, from stellar mass black holes in GRBs to supermassive black holes in AGN. Their active cores contain magnetized accretion disks and rotation of the Kerr black hole provides mechanism for jet launching. This process works most effectively if the mode of accretion turns out to be magnetically arrested. In this mode, the modulation of jets launched from the engine is related to internal instabilities in the accretion flow, that work on smallest time and spatial scales. We find that MAD scenario can explain the variability of both stellar and supermassive engines, but in some cases magnetic fields may lead to jet quenching. The effect is important mainly for Gamma Ray Burst jets, where the jet can be chocked inside the magnetically driven winds.

Modeling the GRB jet properties with 3D general relativistic simulations of magnetically arrested accretion flows

Bestin James (Center for Theoretical Physics, PAS, Warsaw)

Abstract: We study the structure and temporal variabilty properties of the GRB jets considering a magnetically arrested disk as their central engine. We numerically evolve the accretion disk around a Kerr black hole using 3D general relativistic magnetohydrodynamic simulations. We consider two analytical equilibrium disk configurations, the Fishbone-Moncrief and Chakrabarti solutions, as the initial conditions and impose poloidal magnetic fields upon them. The disk starts accreting due to the development of the magnetorotational instability and eventually develops to a magnetically arrested accretion disk state. We consider these models to be central engines of short and long-GRBs, based on our initial conditions, and investigate the properties of the jets launched from these models. Our models self-consistently produce structured jets with a hollow core up to ~ 5 degrees. The jets from our simulations have an opening angle up to ~ 11 degrees for the long-GRB model and up to ~ 25 degrees for the short-GRB model. We also perform the time variability studies of the jets and provide an estimate of their minimum variability timescales. Our models can be applied to the GRB jets in the binary neutron star post-merger system or to the ultra-relativistic jets launched from collapsing stars.

Formation and survival of the observed cold disc around Sgr A*

Diego Calderón (Institute of Theoretical Physics, Charles University in Prague)

Abstract: The central supermassive black hole of the Milky Way, Sgr A*, accretes at a very low rate making it a very underluminous galactic nucleus. The recent discovery of cold gas (~ 10000 K) on a disc-like structure around Sgr A* raised questions about how such material could settle in such a hostile environment. In this work we show that the observed system of mass-losing stars blowing winds can naturally account for both the hot, inefficient accretion flow, as well as the formation of the observed cold disc. We performed hydrodynamic simulations of the observed Wolf-Rayet stars

feeding Sgr A* making use of the grid-based code RAMSES. Our results show that cold material can accumulate close to the black hole in the form of a disc after ~ 3000 yr. Thus, we propose that the observed cold disc can be a natural outcome of the system. Furthermore, we discuss the stability of the disc being subject to the many perturber agents in the region such as the stars, their winds, and the effects of the hot environment.

Ultrafast outflows from galactic nuclei: signature of orbiting body?

Petra Suková (Astronomical Institute, Czech Academy of Sciences, Prague)

Abstract: I will show the results of our GRMHD simulations showing that the body transiting through an accretion disc around a supermassive black hole can expel blobs of matter along the axis of rotation. This matter is accelerated by the organised magnetic field to relativistic velocity. Depending on the position and size of the body this may lead to quasiperiodic modulation of the observed signal. Such observable signatures are of utmost scientific interest regarding the upcoming space-based gravitational wave observatory LISA operating in the mHz range for which the extreme mass ratio inspirals are one of the main targets. Using the information obtained from the electromagnetic signal, we can localize the host galaxy of the EMRI before the final plunge.

2.9 Galactic Nuclei Temporal & Spectral Properties I.

All about jets: precession, variability, and neutrinos

Silke Britzen (Max Planck Institute for Radioastronomy, Bonn)

Abstract: Active Galactic Nuclei (AGN) have been observed since decades with single-dish radio telescopes to monitor their flaring at radio wavelengths. In addition, VLBI has been intensively employed to trace the structural changes in their parsec-scale radio jets. This had led to the view that i) the observed flares are associated with ejections of synchrotron blobs from the AGN core, and ii) most of the flaring would follow a one-to-one correlation with the component ejection. It is thus expected that the combination of the two kinds of information would yield a new insight into the feeding of the central engine (widely believed to be a supermassive black hole) and how this feeding ends up in the ejection of jet components. Recent results have provided mounting evidence that the time-dependent component injection into the relativistic jet may not be the only cause of the flux variability. We propose that AGN flux variability and jet morphology changes can be of deterministic nature, i.e. having a geometric/kinetic origin linked to the time-variable Doppler beaming of the jet emission as its direction changes due to precession. The physics of the underlying jet leads to shocks, instabilities, or the formation of plasmoids. The jet appearance (morphology, flux, etc.) of this underlying jet can be strongly affected and modulated by jet precession. As an exemplary case, we demonstrate this modulating power of precession for OJ 287. For the first time we show that the SED spectral state of OJ 287 can be directly related to the jet-precession phase. We model the SED evolution and reproduce the precession parameters based on the kinematics of the pc-scale jet.

Recent breakthrough results on black-hole magnetospheres from Silesia

Martin Kološ, Arman Tursunov (Institute of Physics, Silesian University in Opava)

Abstract: Extreme conditions in the magnetosphere of black holes cause a variety of interesting phenomena which are the subjects of intensive studies of the modern multi-messenger astrophysics. In this talk we will demonstrate various processes in the combined gravitational and electromagnetic fields taking, which are studied by our research group in Opava: relativistic jets, black hole accretion disks, quasi-periodic oscillations and electromagnetic spectrum generated by charged particle motion. Our intention is to find signature of general relativistic effects indigenous to black hole vicinity.

A multifrequency characterization of the extragalactic hard X-ray sky

Matej Kosiba (Masaryk University, Brno & University of Turin)

Abstract: I will present a catalogue of hard X-ray sources based on the revision of the 3PBC catalogue. The revision was also used to produce a second release of the Turin-SyCAT catalogue of Seyfert Galaxies.

Are the accretion states of AGN and XRBs analogous?

Abhijeet Borkar (Astronomical Institute, Czech Academy of Sciences, Prague)

Abstract: Black holes (BH) are thought to be the same kind of objects with properties that scale with the BH mass. This is supported by the existence of the fundamental plane of BH activity, which relates the BH mass with X-ray and radio luminosity across the scale. The unification between active galactic nuclei (AGNs) and X-ray binaries (XRBs) is important for understanding the process of accretion onto compact objects. We investigate the inherent similarities and differences between AGNs and XRBs, with the primary objective of comparing the accretion states and properties of XRBs with different classes of AGN. The evolution of accretion states and its effects on the observed properties of XRBs has been investigated using the hardness-intensity diagram. To compare the accretion states of AGN, we have created a sample of sources from the simultaneous XMM-Newton X-ray and UV observations and the Swift/BAT AGN Spectroscopy Survey (BASS). We cross-matched the sample with several multiwavelengh catalogs to obtain source properties, such as BH mass, radio luminosity, obscuration and host galaxy properties, and constructed the hardness-intensity diagram for AGN. Here, we will present how different observational properties of AGN and their host galaxies are correlated with their observed accretion states as seen in the hardness-intensity diagram. We further explore the analogy and differences with the accretion states of X-ray binaries.

2.10 Galactic Nuclei Temporal & Spectral Properties II.

The Imaging X-ray Polarimetry Explorer (IXPE)

Giorgio Matt (Roma Tre University)

Abstract: The characteristics of, and first results from, the Imaging X-ray Polarimetry Explorer (IXPE), launched on December 9, 2021, are presented and discussed.

Shining light on the census of supermassive black hole accretion with NuLANDS

Peter Boorman (Astronomical Institute, Czech Academy of Sciences, Prague)

Abstract: Most mass is accreted onto supermassive black holes behind thick columns of gas and dust in the nuclei of large galaxies. An accurate assessment of the material feeding and obscuring the central engine in Active Galactic Nuclei (AGN) provides important insights into the co-evolution of supermassive black holes and galaxies across cosmic time. However, current estimates of the heavily obscured AGN fraction vary drastically between $\sim 10-60\%$ of the entire population, and it remains unclear what drives this broad range. A striking handicap of previous works has been the inability to effectively select heavily obscured AGN with approximately equal probability relative to the (often brighter) less-obscured AGN population. To investigate such issues, I will present NuLANDS - one of the largest NuSTAR legacy surveys ever performed based on joint far-IR/X-ray constraints, aimed at constructing an obscuration-unbiased census of AGN in the local Universe. In this talk, I will highlight the importance of multi-wavelength selection in bypassing obscuration biases and describe the computational challenges faced when uniformly exploring complex multi-dimensional parameter spaces for many sources. I will then present the first results from NuLANDS, finding the fraction of heavily obscured AGN to be consistent with the most recent predictions from Cosmic X-ray Background modelling. NuLANDS thus marks a major step in completing the census of supermassive black hole activity in the nearby Universe and will provide vital insights into the densest regions of the AGN obscurer.

Peering through the veil: using hard X-ray spectroscopy to probe the circum-nuclear environment in NGC 3982

Kristína Kallová (Masaryk University, Brno)

Abstract: Heavily obscured accreting supermassive black holes in the centers of active galaxies offer a unique opportunity to study the circum-nuclear gas in the vicinity ($D \lesssim 20$ pc) of the central engine. To understand the geometry and structure of the obscurer, the observed spectral shape in the hard X-ray band is crucial. NuSTAR is the first high-sensitivity focusing hard X-ray telescope in orbit, making it essential for such challenges. In this talk, I will present a detailed study of the circum-nuclear obscurer in Compton-thick AGN candidate NGC 3982. I fit several physically-motivated obscurer models to the broadband X-ray spectra from XMM-Newton and NuSTAR to provide physically-meaningful constraints on the circum-nuclear gas under unique model geometries. The use of global parameter exploration provides inter-parameter dependencies and degeneracies whilst ensuring issues with local minima are avoided. All models used agree that the source

is Compton-thick, though I will also highlight the effect of different geometrical assumptions on other key system parameters such as intrinsic X-ray luminosity. I will conclude by presenting some exciting prospects for constraining the geometry of the circum-nuclear region in AGN, with simulated observations from the proposed High Energy X-ray Probe (HEX-P).

Non-thermal emission and acceleration of UHECRs in AGN jets

Anabella Araudo (ELI Beamlines, Institute of Physics, CAS, Prague)

Abstract: Jets from Active Galactic Nuclei (AGN) are non-thermal emitters in the whole electromagnetic spectrum, from radio to gamma-rays. It is unclear how and where the gamma rays are produced. AGN are also candidates to accelerate ultra high energy cosmic rays. Although their origin is still under debate, recent theoretical and experimental advances indicate that the backflows in AGN jets can accelerate particles up to energies larger than EeV. I will present our recent studies to explain the high-energy emission in the inner and termination regions in jets from radiogalaxies, and the acceleration of ultra high energy cosmic rays in their backflows.

2.11 AGN vs. quiescent galactic nuclei: Looking for synergies

Non-thermal radiation from disk-cloud interactions in Active Galactic Nuclei

Ana Laura Müller (ELI Beamlines, Institute of Physics, CAS, Prague)

Abstract: In this talk, we present our results for non-thermal radiation produced by fall-back clouds colliding with the accretion disk in the broad-line region of active galactic nuclei. We find that, in high-accreting systems with broad-line regions well described by the Failed Radiatively Accelerated Dusty Outflow (FRADO; Czerny Hryniewicz 2011), significant non-thermal emission might arise from such cloud impacts, particularly in the hard X- and gamma-ray bands.

Interplay between SED and spectral line profiles in the context of gappy accretion discs

Marcel Štolc (Astronomical Institute, CAS, Prague)

Abstract: Both spectral energy distribution (SED) of the continuum and the spectral lines offer a way to measure and model parameters of the inner and outer region of the black hole accretion disc. We introduce a perturbative term in the orbital plane of the accretion disc and assume different scenarios pointing towards a gappy accretion disc setup. Studying the radiative effects of the perturber, we discuss the application of the methods used to constrain the parameters of the system.

AGN vs. quiescent galactic nuclei: Looking for synergies - CPB2022 meeting summary

Michal Zajaček (Masaryk University, Brno)

Abstract: I will briefly summarize the main differences between quiescent galaxies and active galactic nuclei, but I will also highlight the potential common underlying features. Then I will attempt to connect the central enegines with the large-scale structures, specifically galaxy clusters, taking into account the presented results at the CPB 2022 meeting. I will look at how large-scale distribution of matter affects the local conditions in the center of galaxies (sort of generalized Mach's principle) and naturally, how the activity of central black holes affects the large-scale properties of matter.

2.12 Special lectures

Architecture Gems in Brno

Petr Kurfürst (Masaryk University, Brno)

Abstract: Brno can be considered an exceptionally architecturally remarkable city with different styles that contrast and complement each other. From the imposing medieval Gothic cathedral of St. Peter and Paul and Baroque churches to the parade of modern styles framing the magnificent reconstructions of the city at the end of the 19th century, Art Nouveau and modernism and functionalism of the first half of the 20th century in a unique mix. At that time, the newly formed Czechoslovakia and especially Brno was a world-important place in developing the functionalist movement.

In the late 19th century, major city redevelopment was started by removing fortification walls around Brno, and the city could begin its transformation into a modern metropolis. Old houses and narrow streets around the walls were demolished and replaced by newly built and generously proportioned districts with wide avenues. The building of the Vienna Ring-inspired ring road, conceived as a magnificent boulevard lined with monumental public buildings, also dates from that time. The development of Brno as an economic and industrial center of at least the Moravian region of the Austro-Hungarian monarchy was also significantly reflected in the architecture of the very beginning of the 20th century, represented mainly by the Art Nouveau style. A separate and remarkable chapter was also the work of the Moravian architect Dušan Jurkovič and his noteworthy synthesis of Art Nouveau, British modernism, and Central European folk architecture.

After establishing Czechoslovakia in 1918, Brno integrated the previously independent surrounding municipalities to create a city with a population approaching a quarter million. It was fortunate that young and far-sighted people became the city councilors and chief architects and planners, who invited other modern-minded colleagues to Brno; above all, architect Bohuslav Fuchs, the author of Bank of Moravia, the Avion Hotel, and many other important buildings of the time. Brno functionalism is a chapter in itself: it was not just a style of architecture but a lifestyle. The most "brilliant" building of this type is the world-famous Tugendhat Villa by the German architect Ludwig Mies van der Rohe, now inscribed on the UNESCO List. Other "functionalists" left their indelible footprint in the city, as were Ernst (Arnošt) Wiesner, who designed the city crematorium or Villa Stiassni, architects Josef Kalous and Jaroslav Valenta, authors of the Brno Exhibition Center, and many others.

Figure 2.1: View of the Brno city center from Villa Tugenhat.

Recent decades have brought a new impetus and "new blood" to Brno's life in the form of rapidly evolving scientific, university, and technological activities. Hopefully, this will also be reflected in a new and widely perceived progressive "wave" in the city's architectural development. Promising and quality structures already appear, such as the urban district of the Masaryk University campus.

Chapter 3

Practical information & Social Program

3.1 Language

The official language in the Czech Republic is the Czech language - český jezyk. It uses the latin alphabet. Many people can speak at least one foreign language, usually English or German. The language of Science is English. We will use it for all lectures and in all scientific discussions.

3.2 Currency

In the Czech Republic, for financial transaction and payments, the official currency is the Czech crown or Koruna česká. As of now, the Czech crown – EURO exchange rate is approximately,

$$1\,\text{EURO} \approx 25\,\text{CZK}$$

3.3 Venue and how to get there

The Cologne-Prague-Brno 2022 workshop will be hosted by the **Brno Observatory and Planetarium**, https://www.hvezdarna.cz/en/, formerly known at Nicolaus Copernicus Observatory and Planetarium. Most of the talks will take place in the smaller lecture room with the maximum of 48 people (could be extended by a few more places when necessary). The Ernst Mach medal ceremony on Wednesday June 1st at 18:00 will take place in the 3D digitarium, including the subsequent show in the planetarium.

The **Brno Observatory and Planetarium** is located at the top of **Kraví hora**, Cow Mountain or Monte Bú or just Kravák, which is about 305 meters above the sea level (coordinates: $49°12'16''$ N, $16°35'2''$ E). The closest public transport hub is **Naměstí Míru**, which is essentially at the saddle between Kraví hora mountain (305 m) and Žlutý kopec mountain (330 m) on the opposite side.

When you travel to the Brno Observatory and Planetarium by public transport, there are essentially two ways:

- **From the direction of the city center: Tram stop Náměstí Svobody or *Česká*, tram no. 4 → Náměstí Míru**. See Fig. 3.1 for the illustration of this connection.

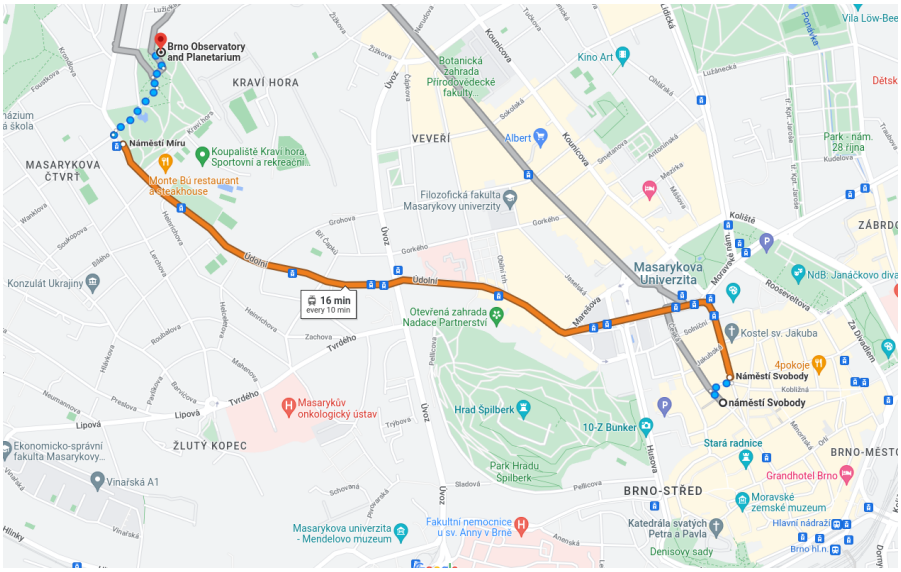

Figure 3.1: Connection to the Brno Observatory and Planeatrium from the city center, using **Tram no. 4.**

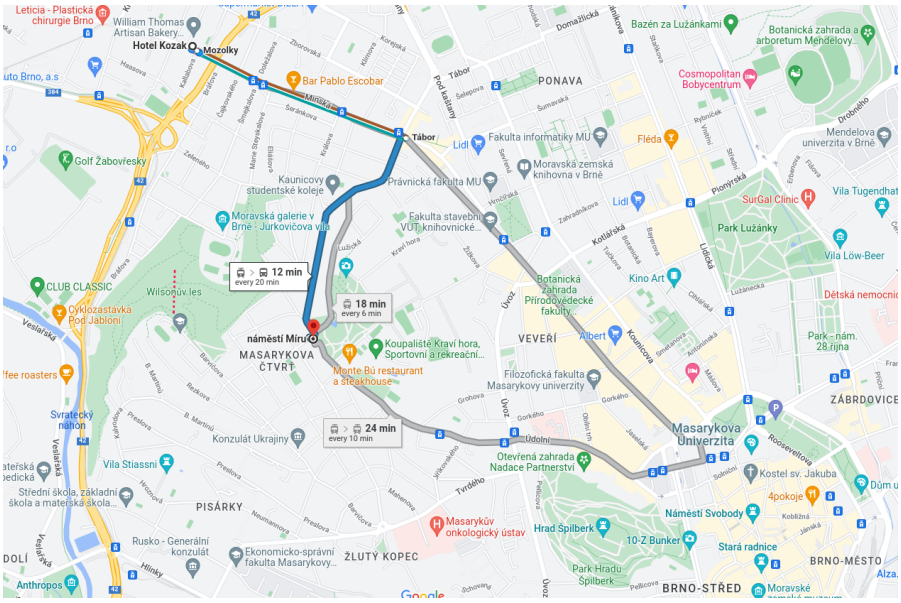

Figure 3.2: Connection from the direction of Žabovřesky, tram stop Mozolky, using **Tram no. 3 or 10**, and then from stop Tábor, one changes to **bus 68** or you can of course always walk if you have time.

- **From the direction of Žabovřesky - e.g. Hotel Kozák: Tram stop *Mozolky* or Burianovo náměstí, tram no. 3 or 10** → stop **Tábor** → change to bus 68 → **Náměstí míru**. See Fig. 3.2 for the illustration of this connection.

3.4 Public transport

There are regular buses and trams in Brno operated by Dopravní podnik města Brna - https://www.dpmb.cz/cs/novinky/all. The connections can easily be found e.g. on Google Maps. The payment system is easy – it is Beep & Go! using your payment credit cards – see the illustration below.

3.5 Prevention against infectious diseases

As you all know, SARS-CoV 2 virus caused a lot of trouble, the current dominant Omicron variant spreads really fast. Currently, the epidemiological situation in the Czech Republic in terms of COVID-19 is really good, with all the restrictions cancelled. Please in case of potential symptoms or contact with a positive person, perform an antigen test (you can buy it in any pharmacy). When you are not sure, please wear the mask, ideally the respirator to the conference venue. In case of a positive test, please stay in your hotel and we will assist you further. For the information concerning COVID-19 in the Czech Republic, please visit https://covid.gov.cz/.

At the moment, there is an epidemic of monkeypox virus. Please be aware that the virus spreads via droplets of body liquids, therefore the spread is more limited than for the coronavirus. There have been 5 confirmed cases in the Czech Republic as of May 26, 2022. For more information, please visit https://www.who.int/emergencies/disease-outbreak-news/item/2022-DON385.

While visiting parks and forests, you should also be aware of infectious diseases spread by ticks. Ticks are parasitic arachnids that are frequently encountered in parks and forests in the spring and the summer, especially when you body parts directly touch the higher grass. Frequent tick-borne diseases are lyme disease and encephalitis, which can actually get dangerous when untreated.

3.6 Social Program

We have scheduled several social events between June 1st and June 3rd. These are in chronological order:

- **Wednesday (1.6.): 18:00, Ernst-Mach Medal and the Opening Banquet** at the Brno Observatory and Planetarium, *Kraví hora 2*, in the 3D digitarium,
- **Thursday (2.6.):** 16:00-18:00 **Visit of Mendel's museum** – *Mendel square 1a* –16:00-18:00; from 18:30 - **Czech-style banquet in the Starobrno Brewery Pivovarská**, *Mendel square 158/20*
- **Friday (3.6.):** 18:30-20:30, **JEAN PAUL'S restaurant**, *Běhounská 4, Brno-střed*; from 21:00 **Air Café**, *Zelný trh 8*

Figure 3.3: Beep & Go! System using credit cards on the Brno public transport.

Figure 3.4: Appearance on the Hyde Park of Civilization, a Czech Science TV program, on May 28, 2022.

- lunch menus everyday between 12:30 and 13:30 at the **Monte Bú restaurant & steakhouse**, *Údolní 532/76*

3.7 Media articles & TV programs

We issued press releases via the Faculty of Science, Masaryk University, and the Czech Academy of Sciences about the Cologne-Prague-Brno meeting 2022 and the Ernst Mach Medal awarded to Andreas Eckart:

- **English version:**
  https://www.sci.muni.cz/en/all-events/u/cologne-prague-brno-meeting-2022
- **Czech version:**
  https://www.sci.muni.cz/clanky/v-brne-se-sejdou-experti-na-hvezdy-v-galaktickem-centru-a-supermasivni-cerne-diry
- **Czech TV *Hyde Park Civilization* dedicated to Prof. Andreas Eckart** premiered on May 28, 2022:
  ENGLISH version: https://www.ceskatelevize.cz/porady/10441294653-hyde-park-civilizace/9271-english-versions/42666-andreas-eckart/
  CZECH version: https://www.ceskatelevize.cz/porady/10441294653-hyde-park-civilizace/222411058090528/

Chapter 4

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