Highly accreting supermassive black holes across all cosmic times: from the Local Universe to Cosmic Dawn

Book of Abstracts

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INVITED TALKS

Hot Dust Obscured Galaxies - The Most Powerful, Obscured Quasars in the Universe

Roberto Assef
Universidad Diego Portales, Chile

Massive galaxies host super-massive black holes at their centers. During periods of intense gas accretion onto the latter, the luminosity of their accretion disks can exceed that of the stellar emission of the galaxy, leading to objects we call quasars. In this talk I will focus on a family of hyper-luminous, obscured quasars identified by the WISE mission referred to as Hot Dust Obscured Galaxies or Hot DOGs. With luminosities that can exceed 10^{14} Lsun, these are some of the most luminous objects in the Universe, yet they are only easily identifiable at mid-IR wavelengths due to their almost Compton-thick obscuration. Their luminosities and high-Eddington ratios make them interesting candidates in which to observe the effects of this energy release onto their host galaxies, usually referred to as quasar-mode feedback. I will review what we know about this population, and other similar and possibly related ones, through studies across the electromagnetic spectrum.

A Multi-Wavelength Perspective on the Growth of Early Galaxies and Supermassive Black Holes

Manuela Bischetti
Università degli Studi di Trieste (Italy)

The advent of JWST has transformed our ability to study gas flows in the first massive galaxies hosting highly accreting black holes. With NIRSpec integral field unit we can map gas physical conditions, metal enrichment, and kinematics with unprecedented $\sim$500 pc resolution, from galactic nuclei to the circumgalactic medium (CGM) - the key interface regulating gas inflows and outflows between galaxies and their environment. At the same time, ALMA provides a complementary view of the cold gas, the fuel for star formation, offering critical insights into the co-evolution of black holes and their host galaxies. In this talk, I will show how the synergy between near-infrared spectroscopy and interferometric data enables a multi-phase characterization of gas flows in and around early galaxies. I will present new strategies to enhance the detectability of black hole-driven winds, including the first clear evidence of a biconical outflow at z$\sim$6.4, and of their long-term impact on the host and CGM gas reservoir. I will discuss new correlations that constrain the ionization and kinematic structure of these winds, providing key constraints for feedback implementation in simulations of early galaxy evolution. This new perspective—treating galaxies as deeply embedded in their surroundings— paves the way for future studies with ELT and SKA, which have the characterization of galactic environments among their major goals.

Chasing the Quasar Wind: theory and observational signatures

Tiago Costa
Newcastle University, UK

This talk concerns the physical processes governing the propagation of quasar winds from accretion disc scales to cosmological distances, and how these processes can be accurately modeled and constrained by observations. I will begin by introducing a new numerical framework designed to bridge the gap between small- and large-scale models of winds, jets, and black hole accretion. Using this framework, I will present new simulations that reveal in great detail how small-scale, quasar winds evolve into large-scale, multiphase outflows. These simulations indicate that quasar-driven outflows are almost always energy-driven, featuring an adiabatic bubble that couples strongly to both the interstellar and circumgalactic media of massive galaxies. Through new sub-parsec simulations, I will present predictions for both the hot and cool components of these outflows. I will argue that the more observationally accessible cool component provides only a biased view of the full outflow structure. In particular, the density of the cool gas scales with wind power and AGN luminosity, significantly affecting outflow rate measurements. I will argue that this predicted scaling, however, offers a subtle and testable prediction of the energy-driven feedback scenario.

The Beguiling Mystery of the Little Red Dots

Jenny Greene
Princeton University, USA

One of the most surprising results from JWST has been the discovery of a large population of compact red sources at $z>4$, with very red rest-frame optical colors, blue UV slopes, and broad Balmer lines. The compact sizes and luminous broad lines strongly suggest these objects are powered by accreting supermassive black holes, but their lack of evidence for X-ray emission or hot dust in the mid-infrared calls that conclusion into question. Regardless, their high number densities ($\sim$5% of the galaxy population) makes them an important new contribution to the high-redshift galaxy zoo. I will discuss our ongoing efforts to understand the nature of this population, and what they may teach us about the growth of black holes and galaxies

Extreme radio variability in early-stage active galactic nuclei

Emilia Järvelä
Texas Tech University, USA

I report on the discovery of extreme 37 GHz radio variability originating from early-stage active galactic nuclei (AGN). Most of these AGN are narrow-line Seyfert 1 (NLS1) galaxies, harbouring fast-growing, low-mass supermassive black holes, accreting at high Eddington ratios. These AGN exhibit amplitude variability of three-to-four orders of magnitude over e-folding timescales of a few days. However, despite our relentless attempts, we have not detected relativistic jets in these sources, and thus, they might be displaying a new kind of variability phenomenon in AGN. Recently, one of these sources exhibited a series of 37 GHz flares and was followed up by several radio and X-ray facilities. Based on these observations, we estimated an e-folding timescale of some hours, leading to variability brightness temperatures and variability Doppler factors that are extremely hard to explain by an incoherent emitter, suggesting a possible detection of coherent emission from an AGN or brightness temperatures far exceeding the inverse Compton catastrophe limit. In this talk, I will present our multiwavelength investigation, including future plans, into this subset of AGN, and discuss the importance of the next-generation astronomical facilities for our efforts to unveil the nature of these extraordinary sources.

Mid-Infrared spectral diversity in optically selected type-2 quasars with JWST/MIRI

Cristina Ramos-Almeida
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We present new JWST/MIRI mid-infrared (mid-IR) spectra of five optically selected type-2 quasars (QSO2s) at z$\sim$0.1 from the QSOFEED sample. Despite similar optical properties and bolometric luminosities (log Lbol= 45.5-46.0 erg/s), these QSO2s exhibit striking diversity in their nuclear mid-IR spectra. Silicate features vary from emission to moderately strong absorption, and two of the QSO2s show absorption bands (e.g., CO, H_2O), revealing different levels of nuclear obscuration among the QSO2s. The atomic emission line ratios (e.g. [NeV]/[NeII], [NeIII]/[NeII]) indicate different coronal line strengths and ionizing continua, and the warm molecular gas properties suggest different gas excitation mechanisms in the QSO2s, going from jet-induced shocks to heating and/or turbulence. Polycyclic aromatic hydrocarbon (PAH) features point to modest nuclear star formation ($\lesssim$ 3-7 Msun/yr) and neutral-dominated PAH populations. These findings highlight the complexity of QSO2s nuclear environments and underscore the need for larger JWST samples to disentangle the roles of obscuration, ionizing continuum, and density, among others, in shaping QSO2 mid-IR spectra.

New and Puzzling Types of Transient Phenomena from Accreting Supermassive Black Holes

Benny Trakhtenbrot
Tel Aviv University, Israel

In this talk, I intend to discuss recent progress in the study of extreme variability and transient phenomena in accreting SMBHs. This includes so-called "changing look" AGN, and other types of UV-bright flares accompanied by peculiar emission features. While these events observationally differ from the (stellar) tidal disruption events known to date, the physics behind them may be interlinked. Together, these transient phenomena can greatly advance our understanding of SMBH accretion, teach us how and why SMBHs turn their accretion "on" and "off", and reveal the sought-after signs of super-Eddington accretion.

Dynamical pc-scale environment in an X-ray changing-look QSO at Cosmic Dawn

Fabio Vito
INAF-OAS, Italy

I will present the discovery of an X-ray changing-look QSO at z=6, which switched from being an unobscured object to a heavily obscured, Compton-thick state in few rest-frame months. X-ray and rest-frame UV monitoring of this object suggests a complex and dynamical environment at pc scales, allowing us to infer useful information on the accretion physics of high-redshift SMBHs.

CONTRIBUTED TALKS

Unveiling hidden black hole growth with optical spectroscopy of IR AGN

Carolina Andonie
Max Planck Institue for Extraterrestrial Physics, Germany

The optical spectroscopic properties of X-ray and optically selected AGN have been well studied, yet these samples mainly probe unobscured, bright AGN, limiting our understanding on SMBH growth. In contrast, IR selection efficiently identifies the key population of highly accreting and obscured AGN missed by traditional surveys. In this talk, I will present the first large optical spectroscopic follow-up of IR AGN, carried out by SDSS-V. Our program targeted WISE-selected AGN down to R<21AB, obtaining 15000 spectra. We complement this with a comparison sample of ∼15000 eROSITA X-ray AGN observed by SDSS. Strikingly, we find that ∼50% of IR AGN lack X-ray detections, suggesting extreme absorption. Through optical spectral decomposition, we measure black hole masses, classify spectral types, and detect outflows. Controlling by redshift, we find 1) IR AGN show stronger dust reddening, with higher Balmer decrements and a greater fraction of Sy1.9 AGN-sources with broad Hα but no broad Hβ. Many also show broad Mg II lines, revealing stratification in the BLR. 2) IR AGN host more OIII outflows than X-ray AGN, though both populations exhibit a positive correlation between outflow velocities/asymmetry and dust extinction. Finally, I will discuss further comparisons between X-ray and IR AGN, which will inform us on the distribution of the obscuring material and AGN evolution. This project is a pilot program to the 4MOST IR AGN survey, which will probe even deeper and more obscured AGN

Quantifying AGN ignition events and state changes with large variability surveys

Patricia Arevalo
Universidad de Valparaíso, Chile

Observations and models indicate that the fraction of active galaxies in the local Universe is about 10%. As most large galaxies host a supermassive black hole (SMBH), this can be interpreted as a duty cycle, where 10% of galaxies are active at any given time. Estimating this activation rate is important to constrain central black hole feeding mechanisms in galaxy evolution models. Black hole ignition events, which involve a galaxy transitioning from a quiescent or star-forming state to an AGN are, however, exceptionally challenging to detect. For our work, we took advantage of the very large public photometric monitoring surveys together with machine-learning algorithms for selecting interesting objects. In this talk I will review our group's results selecting and confirming changing look AGN (López-Navas et al. 2023 MNRAS,518,1531 and 2023 MNRAS, 524,188) and AGN activation events (Arevalo et al. 2024 A&A,683L, 8, and Sánchez-Sáez et al. 2024 A&A, 688, 157) using this approach and complement the analysis by quantifying the number of spectroscopically confirmed AGN that have stopped showing optical variability and therefore might have switched off.

Growth of Central Massive Black Holes and Feedback on Host Galaxies using Cosmological Simulations

Paramita Barai
INAF - Astronomical Observatory of Trieste (Italy), Italy

Supermassive Black Holes (SMBHs) at the centers of high-z quasars are observed to have grown to masses >= 10^9 Msun by redshifts z=6-7. Recent JWST observations are additionally revealing the existence of central intermediate-mass BHs (10^7 - 10^8 Msun) at even earlier epochs z$\sim$10-12; some of which sources have BH mass comparable to the mass of the host galaxy. At the same time, very recent JWST observations have detected a population of normal-mass central SMBHs at z$\sim$3-5, with the mean SMBH-to stellar mass ratio consistent with the local relation. The formation of such supermassive (overmassive and normal-mass) BHs at the centers of their host galaxies involves unresolved questions. I will present results from Cosmological Hydrodynamical Simulations investigating the growth and feedback from SMBHs at galaxy centers. These simulations are done with the SPH code GADGET-3, and includes sub resolution physical processes of radiative cooling, star-formation, chemical enrichment, stellar evolution, SN feedback, AGN accretion and feedback. We investigate the growth of SMBHs, as well as their impact on the host galaxies in terms of star formation quenching and the formation of outflows. Our simulation results indicate that the overmassive BHs underwent periods of Eddington-limited or super-Eddington bursts of gas accretion. In terms of AGN feedback impacting star formation, in zoomed cosmological simulations we find both negative and positive feedback.

Tales of Two Quasars: Diverse Highly Accreting SMBHs from Deep JWST NIRSPEC IFU Observations

Eduardo Bañados (Presented by Julien Wolf)
MPIA, Germany

I present results from two deep (10h each) JWST NIRSPEC IFU programs on contrasting high-z quasars, revealing diverse highly accreting SMBH environments. The first, at z=7.6 (current redshift record), harbours a $2{\times}10^9$ $M_\odot$ black hole from H-β measurements, requiring super-Eddington growth within 700 Myr. Paradoxically, despite achieving one of the deepest z>6 quasar datacubes, we detect no extended [OIII] emission or outflows, only an expanding Balmer shell, suggesting local ISM conditions suppress typical feedback signatures. The second, a jetted quasar at z=6, shows spectacular [OIII], H-β, and H-α halos extending $\geq$20 kpc co-aligned with the jet — first clear evidence of jet-CGM interactions in the early Universe. These contrasting results highlight remarkable diversity in early SMBH environments and demonstrate how deep individual studies are essential for understanding rapid black hole growth and feedback mechanisms at cosmic dawn.

Ultra-Fast Outflows Observed with XRISM

Ehud Behar
Technion Haifa, Israel

Outflows from AGN are the likely agent for cosmological feedback that affects the formation and evolution of galaxies. Since the kinetic power of an outflow scales as $E_K \sim v^3$, it is the fastest winds that are the most promising candidates for this feedback. Ultra-fast outflows (UFOs v > 0.1c) from Supermassive black holes (SMBH) are detected in X-ray spectra as highly blue-shifted Fe K-shell absorption lines above 7 keV. Until recently, they were detected at the moderate spectral resolution of CCD instruments. In 2023, JAXA launched the XRISM satellite with the Resolve microcalorimeter spectrometer on board. Resolve features unprecedented spectral resolution in the Fe K-shell region. Recently [1], we used Resolve to detect for the first time a UFO with five discrete velocity components between 0.2c - 0.3c. This wind was interpreted as having millions of clumps, totaling a mass outflow rate of 60–300 solar masses per year. Following this discovery in the bright quasar PDS 456, Resolve has been detecting more examples of massive, clumpy UFOs. The talk will describe the discovery in detail, its mass estimates, and its impact on our understanding of UFOs and AGN outflows.

A blazar at z=7: Probing extreme SMBH growth and Jets Physics in the Epoch of Reionization

Silvia Belladitta
Max Planck Institute for Astronomy, Germany

Relativistic jets are thought to play a crucial role in the co-evolution of massive galaxies and their central supermassive black holes (SMBHs). Yet, our understanding of powerful radio sources during or near the epoch of reionization remains limited—posing a significant gap, particularly for future studies aiming to detect 21 cm absorptions (i.e. to study the properties of the Intergalactic Medium) in this early cosmic era. In this talk, I will present the discovery of the most distant radio-loud quasar known to date at $z = 7.0$ – a blazar, whose relativistic jets are pointed toward Earth. This system represents an extreme case of highly accreting SMBH in the early Universe, requiring accretion rates near the Eddington limit to power both its luminous accretion disk and relativistic jets simultaneously. The existence of this blazar implies a population of hundreds of similar, misaligned highly accreting radio sources at $z \gtrsim 7$, suggesting that jet-mode feedback was already established in the early Universe. I will highlight our ongoing efforts to characterize the properties of its powerful relativistic jet across the electromagnetic spectrum, from low-frequency radio observations to X-rays. Finally, I will discuss the potential of this source as a background beacon for 21 cm absorption studies, drawing on new data from my uGMRT and LOFAR observing programs.

Glimpses of the high-z universe with local analogues: a new intrinsically soft Compton-thick AGN

Peter Boorman
Caltech, USA

Recent observations from JWST have revealed an abundance of Seyfert-luminosity AGN at high redshift that lack any observable X-ray counterparts. Current theories provide two reasons for such X-ray deficits: (1) rapid accretion with very soft X-ray spectra akin to Narrow Line Seyfert 1s in the local universe or (2) AGN obscured by Compton-thick levels of obscuration along the line-of-sight. However, no example is currently known of an AGN displaying both a soft spectrum and Compton-thick obscuration at any redshift. In this talk, I will present the first and currently only NuSTAR confirmed Compton-thick AGN with strong indications of an intrinsically soft X-ray spectrum, existing at a mere 22 Mpc from us. By testing multiple model geometries for the obscurer, we show that the observed X-ray spectrum can only be explained with either (i) an extraordinarily steep slope with photon index of $\sim$3, (ii) a remarkably low coronal temperature of $<\sim$ 15 keV or (iii) a combination of both. All three possibilities suggest the source is the first Narrow Line Seyfert 1 confirmed to be obscured by Compton-thick obscuration along the line-of-sight. However, regardless of its accretion properties, intrinsically X-ray soft Compton-thick AGN plausibly represent an entirely new class of obscured AGN that would be essentially invisible to all wide-area X-ray surveys performed to-date. Such sources thus provide a natural explanation for JWST AGN lacking detectable X-ray counterparts at high redshift.

BH merger rates in the first billion years in light of JWST discoveries

Paula Cáceres Burgos
Universidad de Chile, Santiago

Recent James Webb Space Telescope (JWST) discoveries have unveiled an abundance of faint and massive Active Galactic Nuclei (AGNs) at high redshifts (z=4-9), that surpass by 10-100 times the extrapolated bolometric (Bol) and ultraviolet (UV) luminosity functions (LF) from previous AGN surveys. Two main models are proposed to explain these observations: light seeds ($\approx$150$M_\odot$) accreting in episodes of super Eddington luminosity, and heavy seeds ($\approx 10^3$ - $10^5 M_\odot$) growing at the Eddington limit. Future gravitational observatories like the Laser Interferometer Satellite Antenna (LISA) will disentangle these models by detecting BH-BH merger events from mid to high redshifts. We report BH-BH merger rates in the heavy seed scenario using Delphi, a semi-analytical model that tracks baryonic physics across cosmic time through the hierarchical evolution of dark matter halos, down to z=5. In our models, we explore both instantaneous and delayed BH merging, as well as extreme spin configurations (a=0.99, a=-0.99) to bracket BH mass growth. Our reference model is calibrated to simultaneously match galaxy and JWST-AGNs observables. We show reasonable agreement with the Bol LF at z = 6, where BHs must accrete 10 -100 times more gas than in previous works calibrated to pre-JWST data. Regarding BH-BH merger events, our models predict a total of 21.44-29.11 per year at z>5, consistent with previous predictions in the literature.

Radio probes of AGN winds in high Eddington ratio AGN

Sina Chen
Technion Haifa, Israel

High Eddington ratio (L/L_Edd > 0.3) AGN are likely to launch a radiation-driven wind. Does this wind interact with the ambient medium and produce radio emission? I will present a study of the correlations between a parsec-scale radio wind and a broad-line region (BLR) wind in a sample of 20 radio-quiet quasars. The radio wind is defined based on the spectral slope and the flux compactness of the 1-5 GHz parsec-scale emission, and the BLR wind is defined by the excess blue wing in the C IV emission line profile. The high Eddington ratio objects are found to have both radio and BLR wind indicators. This suggests that the BLR wind extends to parsec scales and produces radio emission. Radio is a key to probe the interaction between the AGN winds and the ambient medium.

5000 eyes on AGN feedback: Exploring AGN outflows up to z$\sim$1 with DESI

Chiara Circosta
IRAM, Grenoble, France

Feedback from active galactic nuclei (AGN) is thought to be key in shaping the life-cycle of galaxies. AGN launch gaseous winds, being able to potentially regulate future star formation in their hosts. AGN feedback is a necessary ingredient of theoretical models of galaxy evolution, although proving its role observationally remains a challenge. Moreover, large spectroscopic surveys are needed to characterize AGN outflows in a systematic fashion across cosmic time. The Dark Energy Spectroscopic Instrument (DESI) survey is collecting hundreds of thousands of spectra over a large area of the sky, providing an unprecedented sample to investigate ionized outflows up to redshift $\sim$1. The targets span a wide range in Eddington ratio, including highly accreting AGN. In this talk, I will present recent work aimed at building a statistical understanding of AGN feedback across the galaxy population. In particular, this dataset enabled an ideal avenue to characterize: i) the occurrence of outflows in AGN as a function of redshift, AGN accretion properties, and AGN/host galaxy properties (e.g., AGN luminosity, black hole mass, stellar mass), ii) how the outflow properties of the highly-accreting population compare with the low-accretion counterpart, iii) scaling relations between outflow and AGN/galaxy physical parameters, for a cosmic epoch (z=0-1) overall unexplored so far with such large statistics.

The MUSE view of the host galaxies of highly-accreting low-z type 1 AGN

Miguel Coloma Puga
European Southern Observatory, Chile

Historically, the study of the central regions of Type 1 AGN has been limited by the strong emission of the accretion disk and NLR/BLR which, when combined with the atmospheric

PSF, prevented us from probing the galactic properties in the central regions. Integral field spectroscopy allows us to correct for this effect, and study the unobscured cores of AGN host galaxies with unprecedented precision. Using MUSE data, in this work I present a combined method for modelling and subtracting QSO light in low luminosity AGN alongside results for two such sources, NGC 6328 (z=0.014) and ESO 075-41 (z=0.028), both jetted, gamma-ray emitting and high-eddington (ϵ=0.28 and ϵ=0.22 respectively). After subtracting the QSO emission, I analyzed both the ISM and stellar properties of these galaxies down to their central SMBH's surroundings. In this talk, I will present the results of a detailed study of both the gas and stellar population, the presence and effects of feedback processes, and I will discuss the discovery of an unresolved and yet-to-be identified high-velocity ($\sim$25000 km/s) short timescale ($\sim$1yr) variable emission, unlike anything observed in other variable AGN up to this point.

Super-Eddington Feedback at Kiloparsec Scales: MUSE View of HE 0054-2239

Pierpaolo Condò
University of Rome Tor Vergata, Italy

Super-Eddington accretion is a key mechanism for the rapid growth of SMBHs in the early Universe, yet its signatures and impact on host galaxies remain poorly constrained. Local analogs such as Narrow-Line Seyfert 1 galaxies (NLSy1s), accreting at or above the Eddington limit, offer a unique opportunity to investigate feedback in this regime with high spatial and spectral resolution. We present VLT/MUSE observations of the nearby super-Eddington NLSy1 HE 0054-2239 (Ton S180), part of a survey of high-λEdd AGN aimed at resolving galactic-scale ionized outflows. The unresolved nuclear emission outshines the host by up to three orders of magnitude in the optical, posing a major challenge for detecting faint extended features. We developed a tailored PSF-subtraction and spectral decomposition technique to recover residual narrow-line emission. This reveals a fast, unresolved [O III] outflow in the nucleus and marginal, compact evidence for an extended ionized component. This may indicate a recent outflow onset or confinement within the nuclear region. We also find kinematic asymmetries in the host consistent with a possible inflow of ionized gas, raising questions about the feeding–feedback balance. These results highlight the need for multi-wavelength observations to assess the role of super-Eddington feedback in black hole–galaxy co-evolution.

Optical multi-epoch and spectral analysis of NLS1s with extreme high-frequency radio variability

Luca Crepaldi
University of Padova, Italy

A few decades have passed since the identification of narrow-line Seyfert 1 (NLS1) galaxies as a subclass of active galactic nuclei (AGN). NLS1s show a Seyfert 1-like spectrum, but with emission line widths similar to Seyfert 2. Their observational properties suggest a combination of high accretion rates near the Eddington limit and low-mass black holes, indicating an early AGN stage. Although rare, jetted NLS1s have been discovered. Recently, seven sources with inverted radio spectra and extreme radio variability were identified among radio-quiet and radio-silent NLS1s. They show rapid flares at 37 GHz, increasing flux up to 9000-fold (Jy level) with e-folding timescales of a few hours. In quiescence and at lower frequencies, they reach only mJy levels. Relativistic jets would be the most likely cause, yet no jet traits were detected. So far, only their radio spectra are a common feature. I present these sources and a multi-epoch analysis to search for optical variability and periodicities using public data. A long-term comparison between radio and optical light curves and an optical spectral analysis were also conducted, revealing a scenario completely different from the radio band. The results show no strong optical variability and accretion at a few percent of the Eddington limit. Such radio variability has never been observed in any AGN, making this work key to understanding the phenomenon and possibly unveiling a new AGN population.

Optical traces of jet-NLR interaction: the case of PMN J0948+0022

Benedetta Dalla Barba
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In the study of active galactic nuclei (AGN), some sources have been extensively monitored across multiple epochs and wavelengths. PMN J0948+0022 is one such source, exhibiting significant multiwavelength variability that has yielded valuable insights into AGN structure and deepened our understanding of this entire class. Traditionally classified as a jetted Narrow-Line Seyfert 1 galaxy, recent observations have revealed a composite Hβ line profile more typical of Intermediate Seyfert galaxies. After confirming the robustness of this spectral change, we performed an optical spectral analysis using SDSS, X-Shooter, and MUSE data. This analysis revealed significant variability in the narrow-line region (NLR) features, including the narrow component of H-beta and the [O III] outflow. We interpret these changes as the result of interactions between the NLR and the relativistic jet. These findings offer new insights into changing-look AGN phenomena, highlighting the interconnected nature of different AGN classes and contributing to a more comprehensive picture of AGN evolution.

A New Benchmark for Estimating Black Hole Masses in Distant AGNs

Elena Dalla Bontà
University of Padova, Italy

Accurate black hole mass estimates are fundamental to tracing the growth of supermassive black holes and their co-evolution with galaxies. While reverberation mapping remains the gold standard technique for active galactic nuclei (AGN), its observational limitations make it impractical for large and distant samples. We present the most robust and comprehensive single-epoch mass estimation method currently available, based on broad emission line properties and calibrated against reanalyzed reverberation mapping data. Our approach systematically incorporates the three key physical parameters that govern black hole mass measurements: line luminosity, line width, and the Eddington ratio. By reprocessing archival reverberation mapping datasets with improved detrending techniques, we derive updated calibrations that significantly enhance the accuracy of single-epoch estimators. These tools are immediately applicable to large AGN samples and are particularly well-suited to upcoming and ongoing spectroscopic surveys, including those using JWST. With typical uncertainties of only 0.2–0.3 dex relative to the reverberation-based masses, this method provides a powerful and scalable framework for probing black hole demographics across cosmic time, enabling new insights into AGN physics and galaxy evolution at both low and high redshift.

Clues on obscured BH growth in Little Red Dots

Ivan Delvecchio
INAF Bologna, Italy

Little Red Dots (LRDs) are likely the most enigmatic class of sources discovered by JWST. The origin of their red colors, compactness, X-ray/radio weakness and V-shaped spectra is highly debated. In this context, we present first evidence for dusty torus emission powering the rest-frame MIR at a population level. We perform median stacking of NIRCam, MIRI, and ALMA images of all photometrically-selected (∼500) LRDs found in several legacy fields (PRIMER, COSMOS-Web, SMILES) over the redshift range [z∼4-8] (mean z∼6) to constrain their median spectral energy distribution. We find hints of a rising mid-IR slope up to rest-frame ∼3um (i.e. MIRI 18um/21um bands at z∼6), suggesting AGN-heated dust emission from a torus. This is further corroborated from SED-fitting, which strongly favours the solution with AGN, while forcing a pure galaxy template would overshoot the ALMA upper limit. In this scenario, the best-fit (rest-frame) 6-um luminosity from the torus would correspond to a bolometric AGN luminosity of Lbol $2\text{x}10^{44}$ erg/s: for a BH mass of $2\text{x}10^{7}$ Msun (∼ 1% of the putative stellar mass from SED fitting) this would imply an Eddington ratio of ∼0.1 (hence even larger for smaller BH masses). Besides challenging the BH-star model due to the presence of dust emission, these results reinforce the highly-accreting nature of (obscured) BH growth in the population of LRDs.

Lifetime measurements of young quasars at z∼6 from their UV and optical extended nebular emission

Dominika Durovcikova
Massachusetts Institute of Technology, USA

The billion-solar-mass black holes observed in the center of quasars within the first Gigayear of cosmic history have posed a challenge to our understanding of supermassive black hole (SMBH) growth. The problem is further exacerbated by a population of young quasars with extremely small proximity zones that have been identified at redshifts $z > 6$ — the imprint of their ionizing radiation on their rest-frame UV spectra seems to indicate that these quasars have grown their black holes in less than 100,000 years! If continuous, Eddington-limited accretion is assumed, it is extremely challenging to grow a billion-solar-mass black hole in such a short time. Hence, other mechanisms, such as super-Eddington accretion or highly dust-obscured growth, have to be invoked to explain such rapid black hole growth. In this talk, I will present new results on measuring quasar lifetimes using an independent lifetime measurement that promises to disentangle these two scenarios. We use new MUSE as well as JWST/NIRSpec IFU observations to search for the rest-frame UV and optical extended nebular emission around young quasars, and measure their transverse extent to estimate the quasars' lifetimes from their light travel time. This method yields complementary insights into the accretion history of these young quasars and, together with the proximity zone measurements, provides new insights to our understanding of SMBH growth in the early Universe.

The Light Echo of a High-Redshift Quasar mapped with Lyman-alpha Tomography

Christina Eilers
MIT, USA

The ultraviolet radiation of luminous high-redshift quasars within the Epoch of Reionization carves out large bubbles of highly ionized intergalactic gas in the quasars' environments, making the otherwise opaque Lyman-alpha forest highly transparent at redshifts near the quasar. I will present the first results from the JWST MASQUERADE program, which leverages some of the deepest NIRSpec/MSA observations to date of galaxies in the background and environment of luminous quasars at $z>6$ to tomographically map the quasars' ionized bubbles, enabling a unique opportunity to probe the AGN unification model at early cosmic times. The extents of these bubbles provide model-independent constraints on the quasars' ages based on the light travel time, providing new insights on the puzzle of the early growth of supermassive black holes. Simultaneously, the quasars' highly ionized regions represent a unique laboratory to study the intrinsic ionizing properties and unattenuated line profiles of high-redshift galaxies without absorption by the neutral intergalactic medium to reveal the elusive protagonists that reionize the universe.

Viewing the ins and outs of black hole accretion with XRISM

Luigi Gallo
Saint Mary's University, Canada

The Resolve microcalorimeter on XRISM provides unprecedented energy resolution in the Fe K band of AGN. In several objects, we resolve multiple components in the iron emission lines indicating origins from the inner wall of the torus, the broad-line region, and regions much closer to the black hole. Highly-ionised, clumpy or stratified, multiphase winds are observed, and the ultrafast outflow nature of some are confirmed. Here, we will present observations of AGN (e.g NGC 4151, Cen A, M81*) in various accretion states observed with XRISM during the performance verification phase and highlight how material is falling inward and being ejected in these systems. The power of XRISM demonstrates the Fe K region is an effective probe of the accretion flow in AGN.

Evolution of Radio-Loud Quasars into the Cosmic Dawn

Anniek Gloudemans
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Recent deep all-sky surveys have revealed active galactic nuclei (AGN) and quasars out to redshifts of $z \sim 7$, providing critical insights into the formation and growth of the first supermassive black holes (SMBHs), galaxies, and large-scale cosmic structures. Among these, quasars with powerful radio jets offer a unique window into the early Universe: their jets not only influence galaxy evolution through AGN feedback but may also facilitate SMBH growth by extracting rotational energy from the accretion disk—potentially enabling super-Eddington accretion. In this talk, I will present the largest sample of radio-loud quasars at $z > 5$ to date, identified by the Dark Energy Spectroscopic Instrument (DESI) survey. This constitutes the first uniform spectroscopic dataset to characterize their emission-line properties and trace their evolution. I will also highlight recent discoveries of the most extreme high-redshift radio quasars, uncovered through Square Kilometer Array (SKA) pathfinders such as the Low Frequency Array, and discuss their properties as revealed by recent JWST observations. I will conclude by outlining the transformative role the SKA will play in advancing our understanding of SMBH formation, pushing to even higher redshifts and probing the faint end of the AGN population, including Little Red Dots.

Pushing the quasar redshift frontier with Euclid: a new era for z>7 quasar searches

Francesco Guarneri
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Luminous quasars at high redshift ($z \gtrsim 7$) directly probe the buildup of supermassive black holes, the primeval galaxies hosting them, and the intergalactic medium during the epoch of reionisation. However, such objects remain rare and challenging to identify due to their faintness and scarcity. The launch of the Euclid satellite is dramatically changing this picture: the wide surveyed area, photometric depth, and wavelength coverage will allow us to push the redshift frontier well beyond $z{\sim}7$. In this talk, I will describe how we, the QSO Work Package, are actively exploiting the wealth of data made available by the Euclid collaboration and introduce our selection methods. I will focus on a novel machine learning approach that combines generative, classification, and regression models and show that it allows for an efficient and complete selection. I will then showcase how, in just 1.5 years, we more than doubled the number of known QSOs at $z>7$ and pushed the redshift frontier further into the epoch of reionisation. Finally, I will conclude by presenting the first results of multi-wavelength follow-up of these newly discovered objects.

X-ray investigation of possible super-Eddington accretion in a radio quasar at z = 6.1

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How the supermassive black holes (SMBHs) we observe in the early Universe formed and grew to the observed sizes in such a short period of time is still not clear. While the formation of already massive black hole seeds may help explain the most extreme cases, super-Eddington accretion is likely required to account for their observed multi-wavelength properties. In particular, recent studies suggest that the strong upper−limits on the X-ray emission of the z>4 BHs discovered with JWST can be naturally explained in the context of super-Eddington accretion. In this talk, I will present a comprehensive multi-wavelength study of RACS J0320-35, a radio quasar at z=6.1. Dedicated Chandra observations revealed an unusually strong and soft X-ray spectrum, with a luminosity of Lx=1.8e46erg/sec and a steep photon index of Γ=3.3$\pm$0.4 |making it one of the most X-ray luminous quasars currently known at $z > 5.5$. By analysing the full spectral energy distribution (SED), we show that the observed soft X-ray emission (1) cannot be produced by relativistic jets, even accounting for Doppler boosting—supported by the faintness of its VLBI-scale core-and (2) is consistent with predictions for a super-Eddington accreting SMBH, based on both theoretical models and lower-redshift analogs. Given its exceptional luminosity across the electromagnetic spectrum, RACS J0320-35 provides a rare and valuable laboratory for directly testing theoretical models of super-Eddington accretion in the early Universe.

Inside the Belly of the Beast: A Sharp New Look at AGN Feedback with AO-Assisted MUSE

Stephanie Juneau
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NGC 7582 is a nearby galaxy with a heavily obscured active galactic nucleus (AGN). Prior MUSE integral-field spectroscopy revealed a 600 parsec circumnuclear star-forming ring and a striking biconical ionized outflows extending over kiloparsec scales. This inner ring likely helps collimate the AGN-driven wind and contributes to the heavy nuclear obscuration. Using MUSE with adaptive optics, we resolve the central region at <0.1arcsec (10 pc) spatial resolution. This unprecedented view reveals a previously unseen compact ionized outflow (10 pc across) embedded within the known large-scale outflow bicone. The small-scale outflow originates in the immediate vicinity of the AGN, carrying high-velocity gas that was blurred in earlier data. It lies fully inside the footprint of the kpc-scale outflow, indicating a nested, multi-scale wind structure. The discovery of this inner outflow demonstrates that AGN feedback in NGC 7582 operates on nested scales from 10 pc to over 1 kpc. Our findings underscore the importance of high-resolution IFU observations in linking the nuclear wind launching region to its galaxy-scale impact. NGC 7582 now serves as a striking example of how an obscured, highly accreting AGN can drive multi-scale outflows and interact with host galaxy substructure as part of the feedback process. While such studies are currently limited to nearby or lensed galaxies, they preview the capabilities of future 3D spectroscopic observations at high redshift with JWST and ELTs.

JWST census of Type 1 AGN from Cosmic Noon to Reionization

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The origin and evolution of supermassive black holes as well as their interaction with their host galaxies still holds many unanswered questions such as the uncertainty surrounding the seeding and growth of the first supermassive black holes embedded in first galaxies. The launch of JWST was expected to shed more light on this domain by probing the low mass, low luminosity end of the active galactic nuclei (AGN) distribution - a regime missed by previous all sky surveys which were sensitive only to the brightest objects. However, first years of results have revealed some peculiar properties of this low luminosity AGN population. Among the more notable ones being their offset compared to the local black hole mass - stellar mass relation and prevalence of absorption features in their broad lines. In this talk I will present a robust sample of Type 1 AGN from the JADES survey spanning redshifts 2 to 9. I will focus on the redshift evolution of the BH - host galaxy scaling relations, the contribution of faint AGN to the UV luminosity function and the presence of overmassive black holes in the high redshift universe. In addition, I will discuss the occurance rate of Balmer absorption features in faint Type 1 AGN and Little Red Dots, focusing on the physical implications. I will also explore how deep JWST IFU data can be used to kinematically constrain BH masses out to redshift 7.

Multi-wavelength view of extreme accretion in local AGN

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Super-Eddington accretion in Active Galactic Nuclei (AGN) plays a key role in understanding rapid growth of supermassive black holes (SMBHs), particularly in the early Universe. However, the accretion disc properties, and the interplay between the accretion disc and X-ray corona are still poorly understood, especially in the super-Eddington regime. Studying spectral energy distribution (SED) of local Universe AGN in this rapid phase of SMBH growth can provide important constraints on changes in the accretion mode. Theoretical models predict that the disc emissivity changes dramatically in this stage, and thus significantly affecting the appearance of the SED. For the first time, we obtain the SEDs of a well-defined sample of super-Eddington accreting AGN in the local Universe via light decomposition between the AGN and host galaxy with the new GALFITS tool, a powerful updated version of GALFIT. My work uses various disc models to fit the simultaneous optical-to-X-ray SEDs of local super-Eddington AGN to provide better constraints on the accretion mode and disc structure in the most rapid phase of the SMBH growth. By deriving fundamental AGN properties such as the X-ray bolometric corrections and optical-to-X-ray spectral indices I also compare to a sample of local sub-Eddington AGN matched in black hole mass.

The Hunt for Lyman-α Emitters around High-z Radio-loud Quasars

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Highly accreting quasars at z>5 are predicted to reside in highly biased peaks of the dark matter distribution in the universe, surrounded by galaxy overdensities extending up to several Mpc. While recent studies have detected such enhanced environments, most were focused on individual fields and targeted radio-quiet quasars (RQ-QSOs). Although radio-loud quasars (RL-QSOs) are found in the most overdense regions at cosmic noon, their environments at higher redshifts and the influence of radio jets in shaping them remain largely unexplored. We investigated the fields of 18 high-z RL-QSOs, with redshifts spanning 3.6<z<6.4, using MUSE observations to search for Lyman-alpha emitters (LAEs) within FoV areas covering ~4-6 cMpc^2. We detect LAEs in several fields, with significant field-to-field variations. Additionally, some LAEs display interesting asymmetrical spectral and spatial profiles. We compare the number of LAEs in our fields with expectations from blank fields (i.e., with no quasars) and those around RQ-QSOs at similar redshifts, accounting for observational depth and completeness. Although our findings indicate that RL-QSOs reside in diverse environments, they are overall located in overdense regions. These results offer new insights into how the environments of high-z quasars shape massive structures in the early Universe.

Binary SMBHs and the Case of OJ 287: Downsizing the Giant Primary Mass, And Other Recent Results

Stefanie Komossa
MPIfR, Germany

Galaxy mergers and the binary SMBHs at their centers are a key component in understanding the galaxy-SMBH (co-)evolution. Gas-rich mergers represent phases of extreme accretion and SMBH growth, a high fraction of mergers is now discovered with JWST at high redshift, and the recent detection of a GW background signal is consistent with a population of massive binary SMBH mergers across cosmic times. Therefore, the search for individual, nearby, evolved binaries is in full swing. The best-known candidate for such a compact binary system is the blazar OJ 287. Here, we present new results from the project MOMO. It is the longest, densest, multi-frequency monitoring program of any binary SMBH candidate carried out to date (e.g. Komossa et al. 2023). MOMO also provides multiwavelength coverage quasi-simultaneous to Event Horizon Telescope (EHT) observations of OJ 287, and sheds new light on disk-jet physics independent of a binary's presence. Among other results, MOMO has clearly established that the timing of OJ 287's famous, giant, double-peaked outbursts is inconsistent with a heavily precessing orbit. The first direct primary SMBH mass measurement yields $10^8 M_{sun}$, a factor of 100 lower than used in the previously leading binary model. These results also rule out the previously leading binary model and the physical processes it involved, with significant implications for binary populations and binary search strategies in upcoming transient surveys at multiple wavelengths.

The Dichotomy in the Nuclear and Host Galaxy Properties of High-redshift Quasars

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The early growth of high-redshift quasars and their host galaxies raises critical questions about their cosmic evolution. We exploit the angular resolution and sensitivity of NIRCam to investigate the host galaxies of 31 quasars at $4 \lesssim z \lesssim 7$ drawn from multiple JWST surveys. Using a new multi-band forward-modeling code (GalfitS) that incorporates physically motivated priors, we securely detect and quantify the host emission in 30 objects, while simultaneously characterizing the nuclear spectral energy distribution. The host galaxies of high-redshift quasars are ~ 0.3 dex more compact than star-forming galaxies of comparable mass. A striking dichotomy emerges: luminous "blue" quasars ($L_{5100} \gtrsim 10^{45}\,\mathrm{erg\,s^{-1}}$) reside in bulge-dominated galaxies ($n \approx 5$) and exhibit a narrow range of ultraviolet nuclear slopes (median $\beta_{\mathrm{UV}} \approx -1.4$), while fainter "red" quasars inhabit disk-like hosts ($n \approx 1$) and display a broad range of slopes ($\beta_{\mathrm{UV}} \approx -2$ to 4). These two populations differ markedly in their black hole-to-stellar mass ratios, with high-luminosity quasars showing $M_{\mathrm{BH}}/M_* = 1.2\%$ compared to 4.7% for lower luminosity sources, placing them collectively $\sim$0.6 dex above the local $M_{\mathrm{BH}} - M_*$ relation. This offset likely reflects rapid black hole growth in early gas-rich environments, where feedback from the active galactic nucleus becomes effective.

Formation of black hole seeds within nuclear star clusters at high redshift

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University of Rome La Sapienza, Italy

The JWST has discovered a population of extremely red, unresolved galaxies at high redshift, known as Little Red Dot galaxies (LRDs). There are two main hypotheses for their color: (I) AGN-dominated scenario – LRDs host active galactic nuclei, with emission primarily from the accretion disk. (II) Star-forming galaxy scenario – LRDs are compact, star-forming galaxies where the continuum is dominated by stellar light. In this talk, I present a series of Monte Carlo simulations using Galacticus, a semi-analytic model for galaxy formation and evolution. Our goal is to reproduce the observed stellar mass function of LRDs and their bolometric luminosity function by exploring different black hole seeding prescriptions within nuclear star clusters. Using MCMC techniques, we determine the best-fit parameters and apply a post-processing luminosity model to investigate the physical nature of these galaxies. We explore various black hole accretion models, including episodic super-Eddington accretion, Eddington-limited accretion, and Bondi-Hoyle accretion. Additionally, we incorporate different accretion disk models, such as the advection-dominated accretion flow (ADAF), the Shakura-Sunyaev disk, and a hybrid approach, considering that accretion disks are expected to be radiatively inefficient at both very high and very low accretion rates.

Tracking the Redshift Evolution of Little Red Dots Down to Cosmic Noon with Large-Area Surveys

Yilun Ma
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Little red dots, or LRDs, are an abundant population of red, compact, broad-line objects discovered by JWST at z=5-8. They exhibit a V-shaped SED, with a blue UV continuum followed by a steep rise in the optical, and are otherwise not strongly detected at other wavelengths. No existing models can fully explain their SED shape. Moreover, LRDs are 100 times more abundant than UV-selected quasars above z=5, yet very few have been identified below z=5. This makes their redshift evolution at lower redshifts highly uncertain due to both intrinsic rarity at those cosmic times and the limited survey area of JWST. In this talk, I will present our search for LRDs at z=1.7-5.0 using a combination of large-area, ground-based, multi-wavelength imaging surveys, spectroscopic follow-ups, and JWST observations. I will primarily discuss our results on the redshift evolution of LRDs, which robustly show that their number density drops by nearly a factor of 20 below z=4, whereas quasars display the opposite trend. Additionally, by combining our large-area LRD search with JWST surveys, we identify a luminosity cutoff above which no LRDs are found. Finally, I will comment on the implications of our results for the true nature of LRDs and, more broadly, for the growth of massive black holes across cosmic time.

Black Hole Mass Corrections and X-ray Signatures in Highly Accreting AGNs Across Cosmic Time

Jaya Maithil
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Highly accreting supermassive black holes mark a critical phase in black hole growth, yet their fundamental properties are mischaracterized due to accretion-driven structural changes. In this talk, I will present our multiwavelength investigation of these rapidly growing systems across cosmic time. Using a Fe II-corrected radius–luminosity relation, we developed a new single-epoch mass prescription and showed that, without correcting for accretion rate bias, optical-based masses are overestimated—by a factor of two on average and up to ten in extreme cases. I will then describe our characterization of the X-ray and optical–UV properties of some of the most extreme super-Eddington accretors. We extended key correlations between the X-ray photon index and accretion rate, revealing steeper spectral slopes and confirming that the disk–corona connection persists even at the highest rate. We identified X-ray weakness in a super-Eddington AGN, consistent with orientation effects from a puffed-up slim disk. To extend mass corrections to higher redshifts, we are leading an ongoing HST program targeting 47 quasars with reverberation-mapped masses. I will present preliminary results revealing how accretion influences C IV and Mg II spectral properties. This work is timely, as JWST and upcoming surveys continue to uncover overmassive black holes in the early Universe, highlighting the need for accurate, accretion-aware mass estimates to interpret black hole and galaxy co-evolution.

Probing the Physical Conditions of Highly Accreting AGN with HOMERUN: From Broad-Line Regions to Ion

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We present HOMERUN, a photoionization modeling framework designed to accurately characterize the physical properties of ionized gas in general, and in AGN in particular, across a wide wavelength range. It reproduces many emission lines within 10% accuracy, enabling precise determinations of metallicity, gas density, and ionization parameter. HOMERUN is particularly suited for "highly accreting supermassive black holes", where emission-line interpretation is complicated by extreme ionizing continua, high densities, and radiation-driven outflows. HOMERUN yields high-fidelity BLR metallicities (1–3 $Z_\odot$), significantly lower than previous estimates, and refined BLR sizes that provide new tests of the radius–luminosity relation, clarifying discrepancies raised by recent near-IR interferometry. This enables more secure black hole mass estimates via virial methods. Beyond the BLR, HOMERUN models NLR emission from the UV to mid-IR, probing gas metallicities in AGN-dominated spectra and enabling comparisons with galaxy scaling relations. Applications to VLT/MAGNUM and JWST/MIRACLE data show HOMERUN also constrains outflowing gas masses and energetics—key to understanding AGN feedback. By delivering precise measurements of ionized gas from the nucleus to galaxy-wide outflows, HOMERUN offers a powerful tool to study black hole growth, feedback, and their impact on galaxy evolution across cosmic time.

The Extreme Local Environments of High-z Quasars

Madeline Marshall
Los Alamos National Laboratory, USA

The environments of high-redshift quasars are a key probe of the formation and growth of supermassive black holes in the early Universe. I will present our work using the JWST NIRSpec IFU to study the local kpc-scale environments of high-z quasars in great detail. In the GA-NIFS program, we have discovered a large number of interacting companion galaxies around our sample of quasars, undergoing major mergers with the quasar hosts. For one of these quasars we have measured a black hole to stellar mass ratio of $\sim$60%, the most overmassive black hole measured to date. As part of the PEARLS program we have also discovered a quasar undergoing a train wreck merger with multiple galaxies and a tidal bridge, with potentially one of the most extreme outflows in the universe. I will show these latest results, and discuss how we can use these new observations to help understand the growth of the first black holes.

Super-Eddington Quasars as Cosmological Probes

Mary Loli Martínez Aldama
Universidad de Concepcion, Chile

Our understanding of the composition, dynamics, and structure of the Universe relies on accurate distance measurements. Quasars, observed up to z<7.6, offer the potential to characterize the matter and energy content of the Universe across multiple cosmic epochs and

to bridge the gap between the late and early Universe. Quasars radiating close to the Eddington limit tend to saturate toward a limiting value, where the luminosity-to-mass ratio (L/M) becomes constant, enabling luminosity to be expressed in terms of the virial velocity field of the BLR (L $\propto$ FWHM^4). Hβ is a reliable virial estimator, however, it becomes inaccessible at z>0.8 to most ground-based telescopes. In the UV range, Al III λ1860 seems to be the best candidate, due to its similar kinematics to Hβ. The use of Al III λ1860 allows us to include sources at higher redshift observed by near-infrared instruments. Through the characterization of the 1900 blend (including Al III λ1860, Si III] λ1892, C III] λ1909, and UV Fe III), we have identified a sample of super-Eddington AGN at $4 < z < 7$ from VLT, Gemini, and Keck telescopes. In this talk, we will present a preliminary Hubble diagram of super-Eddington AGN at $0 < z < 7$, including observations from Al III λ1860 and Hβ. We will also present caveats of the method and discuss future improvements.

Exploring the Ultraviolet Quasar Main Sequence and Its Connection to the Eddington Ratio

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University of Conception, Chile

The Quasar Main Sequence (MS) in the optical regime organizes the phenomenology of the broad emission lines in quasars, providing an ordered change of the broad line region (BLR), primarily governed by the Eddington ratio. This work explores whether this trend extends to the UV regime. Using a sample of 80 low-z ($z < 1$) HST UV spectra (with known optical MS parameters), we found a UV MS using the FWHM of Al III λ1860 and the UV FeIII centered at 2080Å. We also analyzed a sample of 70 UV high-z ($4 < z < 7$) quasars, from VLT, Gemini, and Keck observations. Our results show that UV FeIII emission positively correlates with the Eddington ratio independently of the redshift range. This allows us to set an empirical threshold based on the equivalent width of UV FeIII to identify super-Eddington AGN. This methodology can be applied to search for super-Eddington AGN in ground-based surveys such as SDSS and DESI. Also, it opens the discussion around the emitting zone of the iron ions in the BLR and their close relation with the Eddington ratio.

Highly-accreting quasars and nuclear and host galaxy star formation

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We report on a multi-wavelength study of extreme Population A quasars (xA) — high–Eddington ratio AGN marked by extremely strong optical Fe II — to identify the physical processes powering their radio emission. The construction of a spectral energy distribution (SED) for a sample of ~ 150 xA quasars confirms the presence of a pronounced Big Blue Bump and steep soft X-ray slope consistent with high accretion rates. Additionally, we revealed enhanced far-infrared and radio components indicating a predominance of emission ultimately associated with star formation. To further explore this results, we obtained new VLA L-, C-, and X-band observations, complemented by LOFAR, VLASS, and mid-IR data, and we constructed radio spectra spanning 0.15–10 GHz for a sample of 18 xA quasars. Approximately one-third of these quasars exhibit steep, unbroken power-law spectra consistent with synchrotron emission and FIR power from star formation; another third show composite SEDs while only a small fraction display signatures of compact jets. These results demonstrate that star formation can dominate the radio emission even at radio powers typically attributed to AGN jets. The concurrent presence of enhanced star formation and extreme accretion appears to be a hallmark of a spectral type along the quasar Eigenvector 1 sequence distinguished by extreme metal abundances and high-velocity outflows in both broad and narrow emission lines.

An ALMA [CII] survey of 26 Radio-Loud Quasars at z>5

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Feedback processes are invoked to be crucial in early (within 1 Gyr from the Big Bang) massive galaxy evolution. In particular, radio-jets are thought to play a key role in shaping the host galaxy/black hole co-evolution in highly accreting early AGN. However, despite the fact that the sample of radio loud (RL) quasars at z>5 doubled in the last few years, little is currently known about radio-mode feedback at such redshifts.Initial sub-mm observations of a few RL quasars provide intriguing clues, but any more general result is hampered by the limited amount of data. Here, I will present new ALMA observations of the host galaxies of 26 z>5 RL quasars, aimed at their [CII] line and dust emission, tripling the sample with such data yet. We recover a great variety of cases: 15% of the sources show signatures of mergers and/or complex morphologies, the continuum of 15% of the them is strongly dominated by the radio jet, while 25% have no detections in line nor continuum. We also observe a dearth of massive companion sources in their immediate vicinity, with respect to what recovered around radio-quiet quasars. All these results highlight the complexity of the radio-jet and interstellar medium interactions.

Investigating 3D Maps of Lyman Alpha Halos Around Radio-Loud Quasars at $z > 3.6$

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The rapid growth of billion solar mass supermassive black holes (SMBHs) within 1 Gyr after the Big Bang requires extreme accretion scenarios. Theoretical models predict that these systems reside in highly biased regions, where the accretion is sustained by vast gas reservoirs from the circumgalactic medium (CGM), reaching kiloparsec scales. In particular, radio jets, present in around 10% of quasars, may also play a key role in SMBH galaxy growth; however, the role of radio jets in shaping the CGM remains unclear, with no systematic observations comparing radio-loud (RL) and radio-quiet (RQ) quasars. I present VLT/MUSE observations of 18 RL quasars at $3.6 < z < 6.4$, investigating how radio activity influences accretion environments. We detect 13 potential LAHs, suggesting larger fractions of such emission around

RL quasars than that observed around RQ ones at comparable redshift. Kinematic analysis reveals Lya line velocity dispersions averaging 200-400 km/s, with extreme cases reaching around 1500 km/s, indicating massive halos possibly sustaining extreme accretion. In my talk, I will compare their properties (luminosities, kinematics, morphology, accretion rates) with those of RQ ones. This represents the largest systematic LAH study of high-redshift RL quasars to date, providing crucial insights into extreme environments in the early Universe.

Optical variability characterization of changing-state AGN candidates

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Pontificia Universidad Católica de Chile, Chile

Active galactic nuclei (AGN) are powered mainly through accretion of surrounding material onto their supermassive black hole, exhibiting flux variability across all wavelengths and timescales. A subclass known as changing-state AGN (CSAGN) displays dramatic variability, such as the almost complete appearance or disappearance of broad optical/UV emission lines and disk continuum emission, on timescales as short as 6–12 months. Such extreme variability appears inconsistent with the viscous timescales typically ascribed to accretion disks, suggesting a gap in our understanding of AGN accretion physics. As such, early detection and monitoring of CSAGN can provide clues that aid theoretical developments. However, most CSAGN have been identified from archival studies, well after their CS episodes. We present a statistical characterization of optical single-band and color variability of spectroscopically confirmed CSAGN based on 5-yr ZTF light curves, as well as results of an anomaly detection algorithm trained on these sources, aimed at identifying new CSAGN candidates for spectroscopic follow-up with the 4-metre Multi-Object Spectroscopic Telescope (4MOST) as part of the Chilean AGN/Galaxy Evolution Survey (ChANGES).

A JWST characterisation of hyper-luminous quasars at the epoch of reionization.

Blessing Musiimenta
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Outflows from active galactic nuclei (AGN) play a central role in galaxy evolution, yet their physical origins and scale connections remain unclear, especially at early cosmic times. At cosmic noon ($z \sim 2$–4), studies have shown evidence of a connection between small-scale nuclear winds traced by broad emission lines (e.g. C IV) and kpc-scale winds traced by [O III] in hyper-luminous quasars. However, such investigations have not been extended to the epoch of reionization (EoR), where supermassive black holes (SMBHs) are in their most rapid growth phase. I will present the first JWST/NIRSpec characterization of a sample of $\sim$10 hyper-luminous quasars at $z > 6$, including sources from the HYPERION survey – a multiwavelength program targeting the most luminous quasars at EoR. We analyze rest-frame optical emission to characterise [O III] λ5007 properties and compare these to properties of rest-frame UV lines such as C IV, tracing the nuclear region. Through simultaneous spectral

modeling of broad and narrow emission lines, we estimate black hole masses and investigate the dependence of [O III] λ5007 properties on AGN properties. We aim to test whether the correlations between nuclear winds and kpc winds observed at z $\sim$ 2 persist into earlier epochs. This study sheds light on the nature of AGN feedback during the early assembly of galaxies and SMBHs. I will discuss the implications of the results from this study to models of AGN-driven feedback and SMBH–host galaxy co-evolution.

Unveiling the Drivers of Warm Ionised Outflows Across AGN Accretion Regimes

Payel Nandi
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Outflows are a ubiquitous feature of active galactic nuclei (AGN), spanning multiple gas phases, from highly ionised to molecular, and occurring in both low- and high accretion systems. These outflows are central to the AGN feedback paradigm, believed to regulate star formation and establish the observed correlations between supermassive black holes (SMBHs) and their host galaxies. Yet, the mechanisms driving these outflows remain under debate. We present a comprehensive study of warm ionised outflows traced by the [O III]5007 emission line in a large sample of AGN from the MaNGA survey. Our sample covers a broad range of Eddington ratios and includes both radio-jetted and non-jetted sources. By separating these subgroups, we uncover key differences in outflow properties. We find that AGN with radio jets exhibit significantly stronger and faster outflows, with enhanced velocity dispersions, mass outflow rates, kinetic powers, and momentum fluxes. Notably, the strength of outflows in jetted AGN scales positively with Eddington ratio and shows a pronounced dependence on the presence of polar dust structures. Moreover, we find that powerful, high-accretion AGN are more effective at suppressing star formation within the central regions of their host galaxies. These results offer compelling evidence that radio jets, especially in high-accretion systems, play a crucial role in driving impactful AGN feedback and regulating central star formation.

Accretion disk winds, continuum reverberation mapping, and variability timescale in AGN.

Hagai Netzer
Tel Aviv University, Israel

Most AGN are powered by thin accretion disks extending from a few gravitational radii (Rg) to several thousand Rg. A small, central X-ray corona is the likely origin of the X-ray emission, and a large-scale BLR explains the strongest observed emission lines. All components of this complex system are known to vary on short (hours to days) and intermediate (days to months) timescales. Extensive continuum reverberation mapping (RM) campaigns of a growing number of AGN have been used to explore the origin of the wavelength- and time-dependent continuum variations common to most such sources. Explanations range from disk illumination by the central variable X-ray source, line and continuum variations in the

BLR, disk wind emission, and combinations of the above. In my talk, I will demonstrate that a variable accretion rate due to mass outflow from the disk surface, on the thermal timescale, can explain the changing SED shape and the time-dependent BLR and disk emission. Such winds also modify the growth rate of black holes and explain the commonly overestimated size of the disk. I will demonstrate this hypothesis by applying a global disk-wind-BLR model to several observed AGN, including those with very high Eddington ratios.

JWST's Little Red Dots: Masters of Disguise in the High-Redshift Universe

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The "Little Red Dots" (LRDs) are a puzzling population of compact red galaxies at redshift $z > 4$, identified by JWST. These objects challenge our current astrophysical models in several ways. First, I will discuss the detection of overmassive black holes relative to the stellar mass of their host galaxies. Second, I will address the X-ray weakness problem, where these sources remain undetected in deep X-ray surveys. I will use GRRMHD simulations to show how mildly super-Eddington accretion can fully resolve this issue. Third, I will explore the extremely high stellar densities at the cores of these objects and their potential for triggering runaway stellar collisions, which, in turn, generate massive black holes. To conclude, I will also describe how low-spin halos can generate such a peculiar population and explain the abundance, compactness, and redshift distribution of the LRDs. Throughout the talk, I will also discuss how the LRDs represent a perfect bridge to study other populations of black holes, including black hole seeds at $z > 20$.

Probing Black Holes in Distant Quasars with PRM: 150x faster and more efficient

Swayamtrupta Panda
International Gemini Observatory, NSF NOIRLab

Reverberation mapping accurately determines virial black hole masses for redshifts $z < 0.2$ using the relationship between the Hβ broad-line region (BLR) size and the 5100 Angstrom continuum luminosity established with $\sim$200 AGNs. For quasars at $z \sim$ 2-3, determining the BLR size is time-consuming and limited by seasonal gaps, requiring $\sim$10-20 years of monitoring CIV emission lines. In this work, we demonstrate that an efficient alternative is to use a continuum size-luminosity relation, which can be obtained up to 150 times faster using photometric reverberation mapping (PRM). We outline the method and its feasibility based on simulations and showcase the spectacular first results carried out with ground-based meter-class telescopes equipped with narrow and medium-band filters. We focus on the ESO La Silla 2.2-meter telescope observations with a well-defined sampling rate, which recovers our predictions - a testament to the validity of our scaling relation. These observations provide the scaling factor between the accretion disk and the CIV-based BLR sizes, which is (1) crucial for estimating the masses of black holes at higher redshifts extending beyond the cosmic noon, (2) evaluating the contribution of the diffused continuum emission and assessing the standard accretion disk theory, and, (3) validating quasars as cosmological distance indicators and bridge the gap between the local and early Universe.

Multiwavelength Signatures of Slim-Disk Accretion in Active Galactic Nuclei

Jeremiah Paul
Texas Tech University, USA

To help us understand how supermassive black holes may have grown through episodes of near/super-Eddington accretion, we need observational constraints on how such episodes affect the physics of AGN central engines. At Eddington ratios above ∼30%, the accretion disk is believed to transition at small radii into a geometrically thick and radiatively inefficient 'slim' disk state. This physical change can facilitate the onset of super-Eddington accretion and alter the appearance and output of the central engine and surrounding regions, necessitating a multiwavelength approach of study. I present observational support for the slim-disk accretion state found from nearby samples of both supermassive and intermediate-mass AGNs via tests across radio, optical, ultraviolet, and X-ray bands. I also discuss ongoing work to diagnose the origin of core radio emission in high-Eddington AGNs, as well as some future prospects to observe interactions between AGN emission mechanisms and better understand how much accretion power may be advected directly into the black hole vs. radiated away or ejected by outflows.

Building the Largest Pure Sample of Narrow-Line Seyfert 1 Galaxies with FORS2 Spectroscopy

Sagarika Paul
Texas Tech University, USA

Narrow-Line Seyfert 1 (NLS1) galaxies exhibit narrow permitted Hβ lines (FWHM $<$ 2000 km/s) and strong Fe II multiplets with low black hole (BH) masses ($< 10^8$ $M_\odot$) and high Eddington ratio. The BH masses and predominantly disk-like hosts suggest that NLS1s are an early-stage Active Galactic Nuclei (AGN). They host the lowest mass super massive BHs that can launch relativistic jets and offer insight into the conditions necessary for jet formation. But classifying NLS1s in large samples is challenging due to low S/N ratio. We use FORS2 observations of ∼100 candidate NLS1s to classify the sources and perform detailed spectral modelling of Hβ, [OIII], and the Fe II pseudo-continuum using the Voigt profile. We found 16 Changing-look AGN and a contamination factor of 28% in our data. We study how the line profile of the broad Hβ line changes from Lorentzian to Keplerian motion-dominated Gaussian with the BH mass to determine if the changing line profile is an essential part of intraclass evolution. We also measure the parameters of ionized gas like electron density and temperature to compare with other AGN classes. Studying NLS1s in the local universe, which resembles high-z, AGN allows us to explore BH growth in the early universe.

Probing Quasar Accretion Disks Across Cosmic Time with Medium-Band Reverberation Mapping

Francisco Pozo Nunez
Heidelberg Institute for theoretical studies, Germany

I will present a new photometric reverberation mapping campaign using medium-band filters on the MPG/ESO 2.2m telescope, targeting quasars at redshifts z $\sim$ 2 to 4. The goal is to map the structure of accretion disks during the peak epoch of quasar activity and to determine the scaling relation between the accretion disk and the broad-line region (BLR) in sources that already have CIV-based BLR time lags from spectroscopic reverberation mapping. As a highlight, I will report the first direct measurement of the accretion disk size in the quasar J0455–4216 at z = 2.66, based on a six-month monitoring campaign. The inter-band delays reveal a disk radius of $3.02^{+0.33}_{-0.57}$ light-days ($\sim$500 AU), consistent with thin-disk theory and surrounding a black hole of about 900 million solar masses. One of the quasars in our sample also has a published GRAVITY+ measurement that spatially resolves the BLR, offering a unique opportunity to compare interferometric and reverberation-based size scales at high redshift. I will conclude by highlighting that efficient, high-redshift accretion disk mapping is now feasible, potentially reducing the timescale for black hole mass determinations from decades to just a few years.

Escaping the Bias: A More Complete View of AGN Demographics and Co-evolution from the ALPINE-CRISTAL

Wenke Ren
Shanghai Astronomical Observatory, China

JWST has uncovered a growing population of high-redshift Active Galactic Nuclei (AGNs). A surprising narrative suggests early supermassive black holes (SMBHs) are "overmassive" relative to their host galaxies when compared to local relations. This challenges co-evolution models but is likely skewed by strong selection biases. We present new results from a search for broad-line AGNs within the ALPINE-CRISTAL-JWST survey, using deep JWST/NIRSpec IFU spectroscopy of 18 massive, star-forming galaxies at redshifts 4.4-5.7. We uncovered 7 AGN candidates by disentangling faint AGN signatures from outflows and host galaxy emission. One is a robust detection with a broad H-alpha line (width approx. 2800 km/s), while six others show broader components (widths 600-1600 km/s). Crucially, our SMBHs, with masses of 10^6 to $10^{7.5}$ solar masses, lie close to or below local black hole mass-stellar mass relations. Simulations show this is a consequence of our survey design, which targets massive galaxies, making it sensitive to AGNs that follow local relations but are missed in other surveys. Our results highlight the critical role of selection bias and point to a large population of "normal" or even "undermassive" black holes, essential for a complete picture of AGN-galaxy co-evolution.

The imprint of AGN-driven outflows on the CGM: the case of Lyα halos around high-z quasars

Silvia Carolina Rueda-Vargas
ESO, Germany

AGN feedback has been considered to have a multi-scale effect on the properties of the surrounding gas, from the ISM to the CGM. Studies using cosmological, radiation-hydrodynamic simulations (e.g., Costa et al. 2022) suggest that AGN-driven outflows facilitate the escape of Lyα photons from the galactic nucleus, thereby shaping the properties of extended Lyα nebulae on CGM scales. These predictions tie the feedback from the central SMBH to observable structures in the CGM. I will present our observational test of the theoretical prediction by Costa et al. (2022): using ERIS/VLT, we follow up on a sample of quasars at z$\sim$2-3, which were previously observed with MUSE/VLT and KCWI/Keck to be surrounded by Ly-α nebulae. By tracing the [OIII]λ5007 emission, we map the ionized gas kinematics at ISM scales and characterize the AGN-driven outflows. We have detected kpc scale AGN-driven outflows in all the observed sources. I will discuss how the kinematics and energetics of these outflows correlate with the size, morphology, and kinematics of the previously characterized Lyα nebulae. These correlations offer insight into the multiscale coupling between SMBH activity and CGM emission. Finally, I will discuss the implications of our findings on the theoretical model presented in Costa et al, 2022, and more globally on the imprint that these outflows may have on CGM scales.

Are Little Red Dots Powered by Highly Accreting Supermassive Balck Holes?

Andrea Sacchi
CfA/SAO, Cambridge, USA

Little red dots (LRDs), high-redshift, red, and compact galaxies, are one of the most puzzling discoveries by JWST. The emission of these galaxies has been argued to be powered by accreting 10^7-10^8 Msun supermassive black holes (SMBHs). This claim has crucial consequences for our understanding of how the first black holes form and grow over cosmic time. A key feature of LRDs is their extreme X-ray weakness: analyses of individual and stacked sources have yielded non-detections or only tentative, inconclusive X-ray signals, except for a handful of individual cases. As the most natural explanation, i.e., high obscuration, seemed disfavored by JWST spectroscopic evidence, several authors have suggested that the X-ray weakness of LRDs is intrinsic, due to super-Eddington accretion rates. In my talk, I will show how by stacking X-ray data for 55 LRDs in the Chandra Deep Field South (accumulating a total exposure time of nearly 400 $\sim$Ms) we can, for the first time, test these models. Our results rule out current super-Eddington accretion models and are compatible only with extremely high levels of obscuration. I will present possible ways to reconcile our observation constraints with our current understanding of accretion and high-redshift SMBHs.

Probing Little Red Dots at Low Redshift: Identification and Spectral Analysis of Local Counterparts

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We investigate local analogs of the recently discovered Little Red Dots (LRDs) observed by JWST, using a redshift-stratified color selection constructed across seven bins below z=0.5. LRDs are notable for their extreme compactness, V-shaped spectral energy distributions, broad emission lines, lack of X-rays and rarity at low redshifts. Their astrophysical nature remains uncertain, with proposed scenarios including super-Eddington accreting AGNs, binary massive black hole systems, AGNs embedded in Compton-thick gas, and galaxy formation within low-spin halos. To explore their underlying physical mechanisms, we identify a population of broad-line blue compact dwarf galaxies (BL-BCDs) as plausible low-redshift counterparts. Our approach employs synthetic photometry via synphot to model the color evolution of LRDs with redshift as key emission lines shift across filters, enabling us to define optimized color cuts. These cuts are applied to photometric data from SDSS and Pan-STARRS, yielding a sample of 22,108 objects with DESI spectra, from which we select those with z<0.5 for further spectroscopic analysis. Emission-line modeling is carried out using pPXF and pyspeckit, focusing initially on the 12 most promising local LRD candidates. We perform diagnostic analyses including BPT classification, Balmer decrement and Balmer break characterization, and also estimates of black hole masses and Eddington ratios. We propose these local analogs as nearby laboratories for studying LRDs.

Role of AGN in galaxy evolution in z∼3-11 in JADES deep spectroscopy

Jan Scholtz
University of Cambridge, UK

AGN feedback remains a vital path for the quenching of galaxies in theoretical models. With the recent discovery of quiescent galaxies at z>3, identification of typical AGNs at high redshift became more essential than ever, to explain the ever-growing population of quiescent galaxies. As typical selection techniques such as X-ray and radio observations arent sensitive enough to detect the typical AGN population at high redshifts (z>3), we need to rely on optical emission lines, which are not accessible to astronomers at these redshifts until the launch of JWST. However, typical selection techniques using optical emission lines (such as BPT diagram), fail to reliably select AGN due to low metallicities of galaxies at high redshift. In this talk, I will present the results from JADES survey and its deep NIRSpec observations of 5000 galaxies between z∼3-11. I will describe the selection of AGN host galaxies at high-z using these emission lines. Using this unique state-of-the-art dataset, I will present the first characterisation of moderate luminosity AGN, the AGN driven outflows and their host galaxy properties (such as black-hole masses, star-formation rates, stellar mass, etc.) at high redshifts, tracing the AGN feedback in the first 3 billion years of Cosmic evolution. Lastly, I will present the analysis of deep NIRSpec and ALMA observations of a quiescent galaxy at z∼3 to constrain its quenching pathway via strangulation of the galaxy.

Detection of a low-metallicity gas cloud near the most luminous obscured quasar in the Universe

Devika Shobhana
Universidad Diego Portales, Chile

Massive galaxies hosting obscured quasars represent a critical phase in galaxy–SMBH co-evolution. W2246-0526 at z$\sim$4.601, the most luminous obscured quasar known with super-Eddington growth, exemplifies this phase. Tracing the large-scale gas distribution in W2246 is crucial to understanding the interplay of gas dynamics, star formation, and quasar feedback, with Lyman alpha (Lya) emission serving as a key tracer of the CGM, IGM, and ionized gas. Our deep(20-hr) MUSE observation revealed that the W2246 merger system is embedded in a Lyman Alpha Blob (LAB) with a physical extent of $\sim$111.8 x 99.8 kpc and a total Lya luminosity of 2.087 x 1e44 erg/s, making it one of the most luminous LABs observed in the universe. The Lya morphology shows evidence for quasar-driven outflows, filamentary inflows, tidal structures arising from ongoing galaxy mergers, the presence of young or forming galaxies, and the complex gas kinematics. In this talk, I will focus on a low-metallicity Lya-only cloud 15 kpc from W2246, associated only with faint CO(2-1), but lacking [C II], dust continuum, UV continuum, and other UV lines. We consider four origins for this cloud: (i) a nascent protogalaxy, (ii) a cold-accretion filament, (iii) tidal debris, or (iv) outflow remnant. This feature provides a rare probe of gas accretion/feedback in an extreme quasar environment. W2246 thus represents a unique cosmic laboratory for studying early protocluster assembly and extreme AGN-driven environmental interactions

Super-Eddington accreting black holes in the early Universe

Hyewon Suh
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Recent JWST observations have uncovered a surprisingly abundant population of faint, red objects — referred to as little red dots — at z$\sim$4-7. Together with the presence of supermassive black holes at z>6, this raises questions about the formation and growth histories of early black holes. Current theories proposes two primary pathways for the formation of seed black holes: the death of the first stars (i.e., light seeds) and the direct collapse of primordial gas clouds (i.e., heavy seeds), yet observational confirmation remains elusive. In this presentation, I will discuss the recent discovery of super-Eddington accreting black holes, low-mass black holes in an extreme phase of rapid growth at z$\sim$4 observed with JWST and ALMA. These objects are similar to other faint AGNs identified by JWST but stands out due to its bright X-ray emissions and an accretion rate exceeding 40 times the Eddington limit. Detailed analysis of JWST NIRSpec/IFU observations reveals spatially extended Ha emission, indicative of nuclear-driven outflows and/or mergers. I will explore the implications of these findings for our understanding of origin of seed black holes and their early growth.

Though Miles Apart, One in Heart: X-ray Insights into Super-Eddington AGN Across Cosmic Times

Alessia Tortosa
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Understanding how supermassive black holes (SMBHs) rapidly grew in the early Universe is a central question in extragalactic astrophysics. Here I present X-ray studies of super-Eddington (S-E) accreting active galactic nuclei (AGN) across cosmic epochs, combining results from local Narrow-Line Seyfert 1 (NLS1) galaxies and hyper-luminous quasars at z>6. Broadband X-ray spectral analyses with NuSTAR, XMM-Newton, and Swift show that local S-E AGN have steep continua, low coronal temperatures, and strong reflection components. IRAS 04416+1215, the most extreme source in our sample and in the local Universe ($\lambda_{Edd} = 427$), exhibits a coronal temperature of ~3 keV-the lowest ever measured in an AGN. At the opposite end of cosmic time, X-ray observations of z>6 quasars from the HYPERION sample reveal very steep photon indices and fast UV-driven winds. Leveraging ~700 hours of XMM-Newton observations, we detect a strong correlation between the X-ray photon index and C IV blueshift in 18 luminous QSOs, suggesting a tight link between coronal physics and disc wind kinematics. These findings indicate that early QSOs likely accreted in the S-E regime throughout their formation history. Despite their separation in cosmic time, these QSOs show converging X-ray properties when accreting at high rates. Our results highlight the physical continuity of super-Eddington accretion across ~13Gyr, suggesting that low-z NLS1s offer key insights into the growth of the first QSOs.

The Role of the Eddington Ratio in Shaping the Polar Wind and Dust Distribution in AGN

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The growth of supermassive black holes manifests itself as Active Galactic Nuclei (AGN) and is believed to play a major role in the formation of galaxies. However, the physical processes behind AGN feeding and feedback, and their dependence on the accretion rate, remain poorly understood. Observing nearby AGN at the highest angular resolutions offers a valuable approach to better understand these dependencies. I will present interferometric observations of the dusty material surrounding AGN on parsec scales in the infrared, with a focus on how the dust morphology depends on the accretion rate, particularly for highly accreting objects. In general, mid-infrared interferometric data suggest that, at higher luminosities, there is more dust in the parsec-scale polar winds. Conversely, a detailed study of two highly accreting objects, including the NLS1 nucleus of I Zw 1, reveals a lack of any polar elongation. This implies that any wind may be preferentially launched in the equatorial direction or possibly expelled by strong radiation pressure. In conclusion, compelling evidence is found that the Eddington ratio influences the inner dust structure, most notably the wind-launching region and the direction of the wind. However, a clear picture of the changes with accretion rate as well as of the of the driving physical processes is yet to be achieved.

Accelerated Co-Growth of galaxies and SMBHs in a z = 3 Proto-Cluster

Hideki Umehata
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We present results from a series of ALMA and JWST observations targeting the SSA22 proto-cluster at z = 3.1. At the core of the proto-cluster, we identify about 20 dusty star-forming galaxies (DSFGs) embedded within extended Lyman-alpha filaments stretching over 4 co-moving Mpc. By combining these data with X-ray observations and JWST/MIRI F2100W imaging, we find that the brightest DSFGs frequently host obscured AGNs—many of which had remained undetected for years. The striking overabundance of both DSFGs and AGNs in this specific environment suggests that the co-evolution of galaxies and supermassive black holes is being accelerated simultaneously along the gas filaments of the cosmic web. High-resolution imaging with ALMA and JWST (resolving down to 350 pc at 1.1 mm) reveals that many DSFGs show disk-like morphologies with embedded spheroidal components in both dust and stellar emission. Several sources harbor compact, luminous dusty cores that likely trace the sites of active bulge and black hole growth. Notably, the brightest DSFG—identified as a massive spiral galaxy hosting an obscured AGN—shows gas flows along dust lanes within a bar connected to a bright dusty core. The estimated bulge-to-SMBH mass ratio aligns with the local bulge mass-SMBH mass relation, suggesting that bar-driven inflows play a crucial role in shaping the early co-evolution of bulges and supermassive black holes.

The curious case of narrow-line Seyfert 1 galaxies in radio

Irene Varglund
Metsähovi Radio Observatory - Aalto University

Narrow-line Seyfert 1 galaxies (NLS1s) are a peculiar bunch of active galactic nuclei (AGN). These sources are characterized by their optical spectral properties: full width at half maximum (FWHM) of the broad Hb emission line being a maximum of 2000 km s^{-1}, and (S[O III]/S(Hb) < 3). Due to these sources being identified based on their optical properties, they are rather unified from an optical perspective. However, due to their spectra occasionally resembling those of other sources, especially when using low-quality data, NLS1s are frequently misclassified. This study uses the largest clean sample available of NLS1s with 3998 sources. In this study, these nearly 4000 sources were studied at three radio frequencies: 144 MHz, 1.4 GHz, and 3 GHz. Originally, it was believed that these sources could not harbor significant radio emission, however, these sources have been proven to be capable of launching and maintaining powerful relativistic jets, thus showcasing significant radio emission. Although NLS1s are quite unified from the optical perspective, their behavior in radio is anything but unified. Nearly half of the sample has been detected at the used frequencies, with some of the sources having Jy-level detections. This study also includes analysis of the spectral index, radio luminosity, and general optical spectral properties of the sample. With this study, it is finally possible to study the population-wide characteristics of NLS1s in radio.

The Millimeter versus X-ray Relation in the Most Rapidly Accreting SMBHs at z<0.16

Sophie Venselaar
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A correlation between the millimeter (mm) and X-ray emission from the nuclear regions of Active Galactic Nuclei (AGN) has been established for nearby and low bolometric luminosity (L_{bol} <1e45 erg/s) sources, suggesting that both originate from the same region: the X-ray corona. This correlation is an important tool for studying highly obscured AGN since mm emission can penetrate higher column densities than X-rays. A correlation between X-rays and UV has been known to exist as well. However, for more luminous and highly-accreting AGN, the UV-to-X-ray correlation has been shown to break down, but it remained unknown whether the mm would follow the UV or the X-ray emission. Calibrating these relationships is crucial to studying AGN at higher redshifts (z $\sim$ 1-2) since nearby, luminous AGN probe a similar luminosity range. In my work, we investigated the correlation of nuclear mm emission with X-rays and UV for nearby AGN with high Eddington ratios and high bolometric corrections. For this, we obtained new high-resolution Atacama Large Millimeter/submillimeter Array (ALMA) observations at 100 GHz and quasi-simultaneous Swift observations, to exclude the possible effects of variability. We found a tight correlation between mm to X-ray for highly-accreting AGN. However, we do observe more mm emission in these luminous AGN compared to less luminous sources. This suggests that additional processes, such as stronger outflows, might be at play.

The first spatially resolved study of feeding and feedback in local super-Eddington AGN

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Super-Eddington (SE) AGN are invoked to explain the early growth and properties of SMBHs at high redshift. Nonetheless, SE AGN are so far poorly understood in terms of their feeding and feedback mechanisms. Local SE sources constitute a unique opportunity to probe this accretion regime in detail, by connecting the properties of the central engine with those of the gas on galaxy scales. I will present our program targeting a sample of extreme local SE (NLS1) AGN with VLT/MUSE optical IFU spectroscopy to map the properties of the extended ionised gas in the host galaxy, complemented with ALMA data for the cold molecular gas and dust (and soon by JWST MIRI/MRS and NIRSpec observations for warm molecular + highly ionised gas and PAH). We characterise galactic outflows (velocity, mass rate) and connect their energetics with that of nuclear X-ray winds and AGN radiation. We find that outflows have limited spatial extension, consistent with being in their initial blow-out phase after the SE episode activation. This study also allows us to probe whether the SE triggering can be primarily ascribed to mergers funnelling gas towards the nucleus or to secular processes. In particular, we find evidence for galactic bar-driven inflows in one target, which may supply the fuel required to sustain the SE accretion. This campaign will provide the first detailed multi-phase, multi-scale study of feeding and feedback in local SE AGN and constitute a critical benchmark for high-redshift studies.

An X-ray and optical spectral study of the changing-look narrow-line Seyfert 1 2MASX J0413-0050

Amelia Vietri
University of Padova, Italy

Changing-look (CL) active galactic nuclei (AGN) exhibit dramatic spectral and flux variations, caused by changes in the accretion rate (changing-state, CS-AGN) or in the line-of-sight column density (changing-obscuration, CO-AGN). Here I present J0413-0050, initially identified as a narrow-line Seyfert 1 (NLS1) galaxy, which was observed in 2004 and again in 2021, showing the complete disappearance of the Hβ line. A third observation confirmed the absence of Hβ and the broad Hα component, along with a significant decrease in the continuum level. Meanwhile, the X-ray flux increased across 3 observations spanning a decade, with a particularly notable spike (2 dex higher) in the most recent spectrum. A new optical spectrum then revealed the reappearance of both the narrow Hβ and the broad components of Hβ and Hα. J0413-0050 may have experienced several switch-on/switch-off phases, with an unknown timescale, potentially affecting the accretion power and thus the optical continuum and the emission lines coming from the broad-line region (BLR). In this talk, I explore all the possible scenarios that could explain these unpredictable variations including CS-AGN behaviour, disc wind or clumpy medium obscuring the BLR, or even BLR 'holidays'. New simultaneous optical/X-rays data I obtained may confirm one of these hypotheses. However, the case of J0413-0050 validates the idea that even highly accreting NLS1s can experience CL phenomena.

A deep X-ray look to the most obscured quasar at z $\sim$ 3.6 and its environment

Ilaria Villani
Università degli Studi Roma Tre, Italy

Hot Dust Obscured Galaxies (Hot DOGs) represent a transitional, dust-obscured phase in the merger-driven evolution of luminous (Lbol> 10^{47}erg/s) QSOs. Owing to dust abundance, this phase is thought to be a key stage of BH growth and AGN evolution. Such systems are expected to host highly accreting SMBHs, possibly caught during a short-lived, buried phase preceding the blow-out. The Hot DOG W0410 (z$\sim$3.6) is one of the brightest (LIR> 10^{14}Lsun), most gas-rich (> 10^{11}Msun), star-forming (>1000Msun/yr) galaxies known. MUSE revealed that W0410 is surrounded by an exceptional swarm of Lyα-emitting galaxies, making this $\approx$400 kpc-scale environment one of the densest known. However, the Lyα nebula around W0410 is only $\sim$30 kpc, much smaller than typically observed around unobscured luminous QSOs at similar redshifts. ALMA detected a massive, fast-rotating molecular disk, challenging the classical picture of chaotic BH growth via major mergers. I will present deep ($\sim$300ks) Chandra observations probing the nuclear emission, heavily suppressed by a Compton-thick absorber (Nh$\sim$ 10^{24} cm^{-2}), making W0410 the most obscured luminous (Lx> 10^{45}erg/s) QSO known at z>3.5. This extreme obscuration may explain the absence of an extended Lyα halo, providing insights into the feedback and escape of ionizing radiation during early BH growth. This multi-wavelength view highlights W0410 as a key laboratory to study highly accreting SMBHs at cosmic dawn, bridging early Universe BH evolution with local analogs.

The brightest quasars in the sky? How massive are their black holes?

Rachel Webster
University of Melbourne, Australia

The origin of black holes with several billion solar masses is an unsolved mystery. We aim to tackle it by discovering the most extreme cases, studying their masses and revisiting assumptions in their estimation. First, we present the All-sky BRIght Complete Quasar Survey (ALLBRICQS), which has completely mapped the bright end of the quasar population at all redshifts. Then we discuss our ongoing work to constrain their black hole masses, which includes (1) long-term reverberation mapping of some of the longest-lag quasars in the sky to calibrate the R-L relation at high luminosity; and (2) observations planned with the VLTI for BLR astrometry, in part for the same objects as in point 1. We will add interesting findings about the accretion states of outstanding objects.

Early black hole growth via super-Eddington accretion: insights from high-resolution simulations

Tommaso Zana
Sapienza, University of Rome, Italy

Super-Eddington accretion may be crucial for explaining the existence of exceptionally massive BHs, exceeding 10^9 solar masses, observed as AGN at high redshifts (z$\sim$6-7). Recent JWST observations strongly support the idea that early BHs grew significantly above the Eddington limit. Concurrently, numerical models are increasingly focusing on understanding the conditions of this extreme accretion process. I have conducted a detailed investigation into the impact of super-Eddington accretion on various BH seed masses within the typical gas-rich proto-galaxy environments at high redshifts (z$\sim$15). I will present results from a state-of-the-art suite of high-resolution SPH, incorporating key physics, including star formation, photoionization, non-equilibrium cooling of primordial species, and a feedback prescription based on the slim disc model. I specifically tested the effects of both seed mass and feedback intensity on the BH growth process. I will demonstrate that, for gas-rich galaxies, even when isolated (i.e., without external interactions), neither star formation nor feedback processes can significantly limit the growth of black hole seeds, regardless of their initial mass. Super-Eddington accretion rapidly leads to the formation of very massive BHs ($\sim 10^5$ Msun) in just a few thousand years, making them overmassive with respect to their host galaxy. I will show that through brief, super-Eddington bursts with small duty cycles, BHs can reach the observed masses by z$\sim$6-7.

FLASH TALKS

Radiation from isolated black holes in the center of super-Eddington galaxies

Leandro Abaroa
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Several types of objects can orbit supermassive black holes (SMBHs) at the center of active galaxies, including massive stars, neutron stars, clouds, and X-ray binaries. Isolated black holes with a stellar origin (BHs of $\sim$10 $M_\odot$) should also be present in large numbers within the central parsec of the galaxies. These BHs are expected to form a cluster around the SMBH as a result of the enhanced star formation rate in the inner galactic region and the BH migration caused by gravitational dynamical friction. However, except for occasional microlensing effects on background stars or gravitational waves from binary BH mergers, the presence of a BH population is hard to verify. In this talk, I will explore the possibility of detecting electromagnetic signatures of a central cluster of BHs when the accretion rate onto the central SMBH is greater than the Eddington rate. In these supercritical systems, the accretion disk launches powerful winds that interact with the objects orbiting the SMBH. Isolated BHs can capture matter from this dense wind, leading to the formation of small accretion disks around them. If jets are produced in these single microquasars, they could be sites of particle acceleration to relativistic energies. These particles in turn are expected to cool by various radiative processes. Therefore, the wind of the SMBH might illuminate the BHs through the production of both thermal and nonthermal radiation.

Fast AGN Characterization in GPU using Spectral Handling and Estimation of AGN Parameters (SHEAP)

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Given the increasing number of Active Galactic Nuclei (AGNs) that will be observed by surveys such as EUCLID, LSST, and 4MOST, there is a growing need for spectral-fitting tools that can efficiently analyze large, heterogeneous samples. To address this challenge, we present Spectral Handling and Estimation of AGN Parameters (SHEAP), a GPU-accelerated fitting code written in Python and built on JAX, a library optimized for high-performance scientific computing on GPUs. SHEAP supports both global continuum fitting and region-specific modeling of the Hα, Hβ, MgII, and CIV emission lines (Mejía-Restrepo et al. 2016), and employs an eigenspectrum-based approach (Rakshit et al. 2020) to decompose host-galaxy and AGN contributions when host contamination is significant. For Fe II emission, users can choose between empirical templates and a physics-driven model that includes thousands of transitions grouped by energy level and scaled by oscillator strengths (Ilić et al. 2022). This flexible Fe II treatment, together with customizable line-profile models, enables reliable characterization of high-accretion systems—such as Narrow-Line Seyfert 1 galaxies

and AGNs with strong outflows. We evaluate SHEAP using well-studied SDSS AGN spectra (both host-dominated and non-host-dominated) across a broad redshift range with existing mass estimates, as well as mock datasets for DESI and 4MOST. Showing SHEAP's speed and scalability for large AGN surveys.

Understanding the triggering of nearby radio-loud AGN

Freya Barwell
University of Sheffield, UK

The expanding jets and lobes of radio AGN are associated with one of the most important forms of feedback, directly affecting star formation histories of host galaxies and influencing the shape of the galaxy mass function. Understanding how they are triggered is key to properly incorporate radio AGN into models of galaxy evolution. They can be characterised by their accretion modes, with the radiatively-efficient radio AGN (e.g. HERGs) accreting at a high Eddington rate (>1%), in contrast with their radiatively-inefficient counterparts (e.g. LERGs) at much lower Eddington rates. Previous studies have suggested that the dominant triggering mechanisms vary between these subtypes, but at low levels of statistical significance. We present the results from a deep INT/WFC imaging survey of a complete sample of all 112 3CR radio galaxies at $z < 0.3$, along with a stellar mass and redshift matched control sample. The results provide the first clear evidence for significant differences ($\sim 3\sigma$) between the triggering mechanisms of the different subtypes of the powerful radio AGN population. The HERGs show a high rate of morphological disturbance ($\sim 4\sigma$ differences with the control sample), consistent with triggering in galaxy mergers and interactions. The LERGs show a much lower rate of morphological disturbance, consistent with the control sample, suggesting that they are triggered via the accretion of gas from the hot X-ray haloes of galaxy clusters.

Constraining the birth and growth of early black holes with JWST observations

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Observations of massive black holes (MBHs) at high redshift (greater than five) challenge our theoretical understanding of black hole seed formation and early growth. We compare JWST observations of high-z MBHs with results from large-scale cosmological simulations (TNG300, EAGLE, SIMBA) in the redshift range between five and seven, finding that theoretical predictions under (over) estimate the observed masses (accretion rates) of MBHs. We thus present a semi-numeric model, based on the Uchuu large scale N-body simulations, that allows us to compute the growth of BHs starting from different seeding and accretion prescriptions. For what concerns seeding, we consider three possible scenarios (PopIII remnants, direct collapse BHs and primordial BHs) that differ in terms of seeding epochs and seed masses. For what concerns accretion, we parametrize the Eddington ratio distribution with a redshift-dependent log-normal, including both super-Eddington accretion and an accretion-dependent radiative efficiency. We determine the free parameters of the accretion model using an MCMC algorithm and exploiting the BH masses observed by JWST in the redshift range from five to eleven. Based on our results, we finally show how JWST observations, particularly at redshifts beyond eight, will play critical role in constraining the origin and growth of the earliest MBHs.

Measurements of black hole masses using the spectral energy distribution of the quasars at z∼6

Fuyan Bian
European Southern Observatory, Chile

In this talk, I will present a study using the accretion disk fitting method to measure black hole masses in quasars at z∼6. The quasar sample includes 42 quasars at a redshift range of $5.8 < z < 6.5$ selected from the XQR-30, which is an ESO large program to obtain deep X-shooter spectra of quasars at z∼6. We derived the supermassive black hole mass using the slim and thin disk models adopted from XSPEC, as well as MCMC Bayesian Inference to fit the quasar broad band photometry. Comparing to the blackhole mass derived using CIV, the back hole mass derived from the SED fitting better agree with that derived using MgII. This provide a unique opportunity to estaimate the black hole mass in a large sample of quasar without decent near-IR spectra in the future large scale quasar survey, such as Rubin Observatory, LSST survey.

ZTF Optical Variability of Highly-accreting Intermediate-mass Black Holes and small-SMBH

Ernesto Camacho
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Driven by the crucial role that highly-accreting intermediate-mass black holes (IMBHs) play in advancing our understanding of supermassive black hole formation, evolution, and host co-evolution, this study explores the optical variability characteristics of IMBH candidates. The robust detection and confirmation of IMBHs remains challenging, making them an elusive population. Using a sample of spectroscopically selected IMBH candidates from the literature, which includes many potential highly and super-Eddington accretors, we characterize their optical variability properties as a function of inferred intrinsic properties (exploring features such as Z-MAD, excess variance, and power spectral density analysis on light curves). For strongly variable IMBH candidates, we explore whether these features can serve as indicators of the presence and properties of IMBHs. The combination of these methods allows us to capture different aspects of variability, such as significance, amplitude, and temporal characteristics, providing a comprehensive approach to defining a distinct subset of IMBH candidates and investigating their implications within the AGN paradigm. Our methodology should be transferrable to upcoming data from the V. Rubin Telescope.

Investigating a Changing-state Event in ZTF18abuamgo

Joel Carpenter
University of Southampton, UK

Understanding the mechanisms behind rapid spectral transitions in Active Galactic Nuclei (AGN) remains a key challenge in extragalactic astrophysics. Changing-Look (CL) AGN — in which broad emission lines emerge or vanish on timescales of months to years — defy standard expectations based on the physical extent of the accretion disc and broad-line region (BLR) surrounding supermassive black holes (SMBHs). These transitions provide a rare window into accretion state changes in real time, particularly in systems with high or variable accretion rates. In this contribution, I present the "turn-on" transition of the CL AGN ZTF18abuamgo, monitored over four years with multi-epoch spectroscopy. I extract, for the first time, the physical properties of a rapidly evolving BLR in a CL source, enabled by the appearance of broad Hydrogen Balmer emission lines. I will also discuss how CL phenomena complicate single-epoch SMBH mass estimates, with implications for black hole scaling relations and the demographics of actively accreting SMBHs across cosmic time.

On the Origin of the $z \gtrsim 6$ Little Red Dots Discovered by JWST

Saksham Chandna
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JWST has uncovered a population of compact "Little Red Dots" (LRDs) at $z \gtrsim 3$, characterised by red rest-frame optical colours and blue rest-frame UV slopes. Their physical nature remains uncertain, but many are suspected to host obscured AGN, making them valuable probes of early SMBH growth and evolution. To investigate this population, we develop a detailed framework to model the photometric properties of massive AGN-hosting and purely star-forming galaxies extracted from GADGET-3 cosmological simulations. Using SKIRTv8 radiative transfer calculations, we generate synthetic SEDs for sources at $z = 6$–9, exploring variations in dust properties and intrinsic AGN SEDs. Applying LRD selection criteria to the simulated sources, we identify both AGN hosts and star-forming galaxies as LRD candidates. By analysing their decomposed spectra and attenuation characteristics, we investigate the physical factors driving LRD selection and assess how dust reddening affects their classification. In particular, we identify distinguishing features that can help isolate AGN-dominated LRDs from purely star-forming analogues. Our results provide new theoretical constraints on the nature of this population, offering a framework to interpret JWST observations. By bridging simulations with photometric selection techniques, this work contributes to refining searches for faint, rapidly accreting AGN at high redshifts and informs theoretical models of early SMBH formation, growth, and feedback.

SOARing into a triple-peaked puzzle: A peculiar OIλ11297 profile in a NLSy1

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We report the detection of a remarkably asymmetric profile in the broad OI λ11297 emission line of the NLSy1 galaxy 2MASX J05014863–2253232, based on near-infrared spectroscopy with the TripleSpec-4 instrument on the SOAR telescope from 2022 to 2024.The profile exhibits three distinct peaks, with the blue and red components resembling double-peaked emissions often linked to disk-like structures in evolved AGNs. This challenges the coplanar cloud model of the broad-line region (BLR) in NLSy1 galaxies, suggesting that the BLR may exhibit complex kinematics, potentially shaped by non-standard geometry or dynamic processes. The three-peak structure was observed consistently across epochs, with slight temporal variability in the blue and red components. This case underscores the diagnostic power of SOAR spectroscopy for AGN monitoring and motivates future efforts to explore the unusual BLR structure in NLSy1 galaxies.

Environmental Dependences of IR-Bright AGN Incidence in Massive Galaxy Clusters

Benjamin Floyd
University of Portsmouth, UK

The number of active galactic nuclei (AGN) in galaxy clusters has been observed to grow by nearly two orders of magnitude from the local universe to z $\sim$ 1.5. Star formation rates in clusters have also been observed to rise rapidly over this redshift interval. These trends, along with several other recent observations of high-redshift clusters, have led to the idea that this enhanced star formation and AGN activity may be driven by galaxy mergers within the clusters. Since mergers are more efficient in lower mass clusters with smaller galaxy velocity dispersions, the expectation is that AGN incidence should scale inversely with cluster mass. Studies using X-ray selected AGN has offered some support for this model in low-redshift clusters, though with large uncertainties. We select infrared bright AGN from a large, uniform, mass-selected galaxy cluster sample from the South Pole Telescope spanning a redshift range of $0.15 \leq z \leq 1.7$. With these data we explore the incidence of IR-bright AGN in clusters as a function of cluster mass, redshift, and projected cluster-centric radius. We find evidence of an inverse mass relation between the halo mass and the incidence rate of IR-bright AGN along the lines of sight to massive galaxy clusters which further corroborates a merger-driven AGN triggering mechanism in massive galaxy clusters.

AGN Activity in the Cosmic Web: New Insights from DESI DR2

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We present a comprehensive analysis of AGN-cosmic web correlations using DESI Data Release 2's unprecedented statistical power. Leveraging DESI's spectroscopic coverage, we map

AGN distribution across diverse cosmic web environments from dense nodes to sparse voids. We employ the ASTRA (Algorithm for Stochastic Topological RAnking) cosmic web finder, which provides probabilistic classifications into voids, sheets, filaments, and knots specifically designed for large spectroscopic surveys. ASTRA's innovation lies in using random points to trace underdense regions without requiring density field interpolation, making it ideal for DESI's data structure. Our analysis reveals significant environmental dependencies in AGN activity, with ASTRA's probabilistic classifications enabling precise characterization across the cosmic web hierarchy. We observe redshift-dependent evolution in these correlations, suggesting the cosmic web's role in regulating black hole accretion evolved substantially since cosmic noon. ASTRA's ability to quantify spatial correlations among cosmic web components provides enhanced cosmological parameter constraints through non-standard clustering statistics. These results establish new benchmarks for testing cosmological simulations of AGN-cosmic web correlations and demonstrate the power of combining next-generation spectroscopic surveys with advanced cosmic web classification algorithms.

Tracing the feedback of high-z AGNs with LOFAR

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High-redshift (z>4) quasars are essential in studying the growth of supermassive black holes and the evolution of active galactic nuclei (AGN) in the early Universe. The mere existence of black holes with a few million solar masses or more at high redshifts provide constraints on the black hole growth and accretion process. The radio-loud subsample of these sources is of great importance since they can be studied with the highest angular resolution provided by radio interferometric technique. Among them, high-redshift radio galaxies are important ingredients to study the evolution of large-scale structure in the Universe and feedback process since they are often found in the centre of clusters and proto-clusters. We selected three z>4 radio-loud AGN already having high-resolution radio interferometric observations at cm-wavelengths, and bright enough in the Low-frequency Array (LOFAR) Two-meter Sky Survey (LoTSS) to be imaged with international LOFAR baselines. Two of the three objects, QSO J0813+3508, and SDSS J123142.17+381658.9, show rather complex morphologies, with lobes, hot spots, and bridges extending to sizes of 50 kpc, while the third one, QSO J1548+3335, has a relatively compact double structure with a projected linear size of <10 kpc. We discuss the implications of our findings based on data from various radio surveys and multi-wavelength archives.

High-z AGNs in Overdense Environments: Insights from Interacting Little Red Dots

Gaia Gaspar
Saint Mary's University, Canada

Little Red Dots (LRDs) are believed to represent a population of rapidly growing AGNs at redshifts beyond 4. While studies of isolated LRDs are taking us closer to disentangling their puzzling nature, few have explored their role within interacting systems. This talk focuses on two LRD systems from the CANUCS JWST survey showing compelling evidence of AGN activity and close interactions with satellite systems. The first is an LRD pair separated by 3.3 pkpc, forming an overdense region along with three star-forming satellite galaxies at z$\sim$7. NIRCam photometry indicates both LRDs are consistent with dust-free AGNs hosted by quenched galaxies. Their non-parametric star formation histories suggest a synchronized burst $\sim$200 Myr ago followed by coordinated quenching, potentially driven by AGN feedback. In the second system, named The Stingray, the NIRSpec spectrum reveals a broad-line and [O III]-strong emitting LRD, surrounded by three young stellar clumps -possibly merging with the LRD- and a quenched satellite, all within 10 pkpc at z=5.1. Its emission line profile and immediate environment further support the presence of a fast-growing AGN embedded in a dynamically evolving structure. These two case studies mark the beginning of a broader effort to understand the role of interactions and mergers in the early growth of supermassive black holes. They illustrate the potential for environmental processes to shape AGN and host galaxy co-evolution in the very early Universe.

Hyper-Luminous Quasars at Cosmic Noon: Black Hole Growth and Feedback in a statistical sample

Radha Anil Gharapurkar
Hamburg Observatory, University of Hamburg, Germany

QSOs, powered by accretion onto supermassive black holes(SMBHs), serve as powerful probes of the early Universe. Understanding their evolution through quasar demographics reflects the growth and influence of SMBHs over time. The black hole mass function(BHMF) is an empirical tool for mapping the growth of SMBH and constraining theoretical models. The Extremely Luminous Quasar Survey provides the most complete census of luminous QSOs (M1450$\lesssim$-27.5) at 2.8$\lesssim$z$\lesssim$4.5. We obtained near-infrared spectroscopy (GNIRS, LUCI, XSHOOTER, 0.8-2.5 microns) for 58 QSOs at z$\sim$3.5 complementing their optical observations. By deriving robust SMBH masses from MgII and HBeta using single-epoch virial estimate, improving over prior outflow-affected CIV-based method, we aim to use the well-defined ELQS selection function to construct the BHMF and tightly constrain its massive end at cosmic noon, offering new insights into SMBH growth by placing strong constraints on the maximum SMBH mass limit predicted by theoretical models and testing the prevalence of super-Eddington accretion. Leveraging the broad spectral coverage, we probe ionised winds and outflows in luminous QSOs via BLR (CIV) and NLR ([OIII]) features, characterizing the SMBH-galaxy interplay. With sub-mm NOEMA observations of subset, we measure host galaxy dynamical masses and star formation via CO(4–3) and dust continuum and discuss the SMBH–galaxy coevolution at the epoch of rapid black hole growth and its connection to earlier and later epochs

The jet structure, flux variability and repeating partial TDEs in NLS1s

Minfeng Gu (Presented by Wenwen Zou)
Shanghai Astronomical Observatory, CAS, China

The properties of jet structure, flux variations and occasional strong flares are important tools to deeply study the physical process in NLS1s. We made VLBI observations in a gamma-ray NLS1 J2118-0732 and found that the core-jet morphology, significant flux variations, and beaming effect make J2118-0732 resemble a blazar, however with the old diffuse/extended emission indicated from the steep spectrum at low frequencies. We found six NLS1s with large scale jet at projected linear size of 100 up to 940 kpc by searching LoTSS images for the SDSS NLS1 sample. Our follow-up multi-wavelength observations with VLA and VLBA help us understand how these low-mass high-accretion-rate systems can produce jets over 100 kpc similar to the typical powerful jet launcher. We study the long-term radio variability of five gamma-ray NLS1s and find that they are highly variable radio emitters and that there are instances of contemporaneous flaring activity between the radio and gamma-ray bands. However, there are also cases of significant radio outbursts without gamma-ray counterparts. We present the discovery of a repeating partial TDE exhibiting dual flares within around 3 yr in a NLS1 AT2021aeuk, where the second flare results from a collision between the TDE stream and the inner accretion disk, triggering an optical flare while simultaneously partially destroying the X-ray corona. All these diverse results are summarized to help understand the general properties in NLS1s.

The Intermediate-Mass Black Hole Reverberation Mapping Project

Hengxiao Guo
Shanghai Astronomical Observatory, China

Recent JWST discoveries of high-redshift galaxies hosting massive black holes have intensified interest in seed black hole formation, particularly the debate between light seeds from Population III stars and heavy seeds from direct collapse. The detection of compact, high-redshift “little red dots” lends support to the heavy seed scenario, but testing these models requires identifying relic IMBHs that have experienced minimal growth. The Intermediate-Mass Black Hole Reverberation Mapping Project aims to confirm the IMBH nature ($< 10^6, M_\odot$) of nearby AGN through reverberation mapping. By precisely measuring black hole masses and continuum/broad-line lags, we seek to constrain the local black hole mass function and distinguish between seeding pathways. In this talk, I will present initial results from our campaign, including studies of two prototype IMBHs—NGC 4395 and POX 52—and discuss future prospects with upcoming facilities.

Unravelling the mechanisms behind AGN triggering in protoclusters

Mónica Isla Llave
INAF-OAS, Bologna, Italy

The large-scale environment plays a key role in shaping the evolution of galaxies and supermassive black holes (SMBHs) across cosmic time. In galaxy protoclusters (i.e, the progenitors of present-day clusters), the combination of abundant gas reservoirs and frequent galaxy mergers is thought to promote SMBH growth. Observations of protoclusters at z > 2 have indeed shown enhanced fractions of active galactic nuclei (AGN) compared to the field, in contrast to what is typically observed in galaxy clusters. However, comparisons across literature studies are complicated by differences in AGN selection techniques, criteria for identifying non-AGN galaxies, and varying data sensitivities. As a result, the question remains unanswered as to whether the observed AGN excesses reflect true environmental effects or are instead driven by selection biases. As part of my PhD, I am conducting a statistical study of X-ray AGN and host galaxy properties in protoclusters over the redshift range 2 < z < 4, using homogeneously selected and analyzed protocluster and field samples. This approach aims to systematically control for stellar mass and observational biases in order to isolate genuine environmental effects on AGN triggering. In this talk, I will present the results from my statistical analysis, which is primarily focused on prominent high-redshift overdensities such as ZFIRE, Hyperion, SPT2349–56 and others.

A census of the high-z quasar lifetime distribution

Timo Kist
Leiden Observatory, Netherlands

Lifetime measurements of luminous quasars (QSOs), when tied to BH mass estimates, will shed unique light on the physical mechanisms responsible for fueling SMBH growth in the high-z universe. An exceptional probe of these lifetimes is the size of the proximity zones of such QSOs, in combination with the Lyman-alpha damping wing signature imprinted on their spectra by the foreground neutral intergalactic medium (IGM). In the coming years, EUCLID will detect a number of high-z QSOs never seen before, whose exquisite spectra collected by JWST will call for powerful statistical methods to conduct an unprecedented census of their lifetime distribution. We developed a state-of-the-art Bayesian inference pipeline that allows us to disentangle the IGM absorption imprint from a QSO's unknown intrinsic spectrum and infer its lifetime to 0.2-1.0 dex, as well as the HI column density in front of it to 0.2-0.9 dex, also constraining the global timing of reionization. We account for covariances across the full spectral range caused by IGM transmission fluctuations, QSO continuum reconstruction, and spectral noise. We present a first census of the lifetime distribution of 41 QSOs between z=5.75 and 7.6, based on current ground-based as well as the first JWST/NIRSpec spectra. By analyzing realistic mock observational spectra resembling the distribution of EUCLID QSOs, we provide a forecast of the observational constraints extending out to z=10 that will be achievable in the coming years.

The Hyperluminous, Dust-obscured Quasar W2246-0526: ALMA High-Resolution [C II] Imaging

Mai Liao
Universidad Diego Portales, Chile

W2246-0526 at z = 4.6, the brightest known Hot dust-obscured galaxies (Hot DOGs) – a rare class of hyper-luminous, dust-obscured quasars with accretion rates approaching or exceeding the Eddington limit–, and one of the most luminous objects known in the Universe, serves as an ideal laboratory to study AGN feedback. I will be presenting a study based on ALMA high spatial resolution observations (∼500pc) of the [C II] emission line. The [C II] dynamics is a dispersion dominated system combined with large nuclear outflows. By removing the contribution of the outflows, we show that the nuclear velocity dispersion implies the presence of an SMBH with a mass of log ($Mbh/M_{\odot}$) = 9.80±0.01, and find that the size of black hole sphere of influence is as large as 2.3 kpc. This constitutes the first time a dynamic SMBH mass is measured by resolving the SoI at $z > 2$, and highlights that ALMA high-resolution [C II] observations of obscured luminous quasars hold great promise to increase the number of dynamical SMBH mass measurements in very distant galaxies. On the other hand, our observations reveal spatially resolved, asymmetric nuclear outflows in [C II] with relatively low velocities (Vout ∼ 500 km/s), suggesting interaction with a very dense ISM and W2246-0526 is likely injecting large amounts of energy into its host's ISM, heating it up and, powering galaxy-scale turbulence that may ultimately inhibit star-formation.

Kilogauss magnetic field in the quasar NRAO 530

Mikhail Lisakov
PUCV, Valparaiso, Chile

The launching of ultra-relativistic jets in active galactic nuclei (AGN) is thought to be driven by a combination of black hole spin, accretion dynamics, and strong magnetic fields. Until recently, direct measurements of magnetic field strength near supermassive black holes were scarce. The Event Horizon Telescope (EHT) has provided key constraints on magnetic fields in the vicinity of M87* and Sgr A*, revealing values of several tens of Gauss. For a powerful quasar NRAO 530, where direct imaging of the central engine remains beyond current capabilities, we have used high-resolution VLBI polarimetric observations at multiple frequencies from 15 to 230 GHz to infer the magnetic field strength indirectly through its effects on jet opacity and polarization. Our analysis reveals magnetic field strengths of up to 30,000 G, localized at five gravitational radii of the central black hole. Magnetic fields exceeding 10^5 G pose a serious challenge to current models of accretion flows and may imply unconventional physical conditions or even alternative descriptions of the central compact object. I will also present a recently started project aiming to measure magnetic fields near a dozen supermassive black holes to test existence of such extreme magnetic fields and establish their effect on the jet radio power.

The Balmer break and optical continuum of little red dots from super-Eddington accretion

Hanpu Liu
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The physical origin of Little Red Dots (LRDs)—compact extragalactic sources with red rest-optical continua and broad Balmer lines—remains elusive. The redness of LRDs is likely intrinsic, with a characteristic rest-optical color temperature of ∼ 5000 K. Meanwhile, many LRD spectra exhibit a Balmer break, often attributed to absorption by a dense gas shell surrounding an AGN. We present semi-analytical atmosphere models and radiative transfer calculations showing that a super-Eddington accretion flow can naturally produce both a Balmer break and a red optical color—without requiring external gas absorption or dust reddening. The break arises from a discontinuity in opacity across the Balmer limit, similar to that of early-type stars, but the lower photosphere density of super-Eddington systems, $< 1\text{e-}9$ g/cm^3, implies a significant opacity contrast even at a cool photosphere temperature of ~ 5000 K. Moreover, in the super-Eddington regime, a geometrically thick accretion flow implies an effective temperature in the range 4000—6000 K that is very insensitive to the accretion rate (analogous to the Hayashi line in stellar models). Our model continuum spectra robustly reproduce both the observed Balmer break and optical colors of LRDs, offering a physically motivated explanation for their unique features.

Unveiling the accretion geometry of Mrk 509 through broadband X-ray spectroscopy

Valentina Missaglia
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Nearby AGN offer unique laboratories for testing feedback models that aim to explain the observed correlations between supermassive black holes (SMBHs) and their host galaxies. The nearby, X-ray bright Seyfert 1 galaxy Mrk 509 stands out in this context, as previous observations revealed the presence of a prominent FeKα emission line complex, including both a narrow, neutral and stable core component, and a broad and variable component. In addition blue- and red-shifted absorption lines have been reported, suggesting the presence of out/inflow material. Motivated by this, we obtained a $\sim$100 ks observation of Mrk 509 with XRISM/Resolve. This triggered a series of (quasi-) simultaneous DDT observations with XMM-Newton and NuSTAR to provide strong constraints on the broadband continuum and new insights into the accretion and ejection processes at work in this AGN. We investigated the origin of the X-ray soft excess, to disentangle the contribution of the warm corona and of the relativistic reflection. Reflection from both the innermost accretion disc and colder material (outer disc, torus and/or BLR) is also invoked to describe the multicomponent FeKα emission line, that dominates the broadband spectrum. Two warm absorbers acting as total and partial coverer of the two comptonizing coronae provide a good description of the data, suggesting the presence of discrete inner BLR clouds along the line of sight that produce strong complex absorption in the soft X-ray spectrum.

The temperature profile of AGN accretion disks using chromatic microlensing

Veronica Motta
Universidad de Valparaiso, Chile

The observation of gravitationally microlensed quasars provides direct measurements of the accretion disk structure. The flux variations of the quasar images, induced by the source crossing through the microlens caustics generated by stars in the lens galaxy halos, produce fluctuations on timescales of years. We use emission lines (from the ultraviolet to the optical rest frame) as a reference to estimate the microlensing variability in the continuum of seven quadruply lensed quasars. Chromatic microlensing (i.e., microlensing magnification varying with wavelength) is applied to estimate the temperature profile of the accretion disk in seven lensed AGNs at redshifts between 0.8 and 2.8.

Extreme X-ray variability events among weak-line quasars

Qingling Ni
MPE, Garching, Germany

While strong and broad line emission is a defining characteristic of quasar spectra in the optical and UV, there is a population of type 1 quasars with strikingly weak or no emission lines known as weak-line quasars. We invoke the thick inner accretion disk and outflow (TDO) expected for quasars accreting at high Eddington ratios to explain the remarkable multiwavelength properties of these objects. In the context of this model, extreme X-ray variability events will be observed if there are slight variations in the thickness of the TDO (e.g., rotation of an inner TDO that is somewhat azimuthally asymmetric) or internal motions of the TDO. With the 4-5 X-ray all-sky scans enabled by eROSITA, we studied the prevalence of extreme X-ray variability events among quasars. We found that weak-line quasars show a higher fraction of extreme X-ray variability events compared to other luminous quasars, which supports the TDO model.

The case of AT2022wtn: a Tidal Disruption Event in an interacting galaxy

Francesca Onori
INAF - Osservatorio Astronomico D'Abruzzo (Italy)

The tidal forces from SMBHs can disrupt stars in their vicinity. These TDEs manifest themselves as luminous, transient flares from the nuclei of otherwise quiescent galaxies and represent an important tool to reveal and study dormant low-mass SMBHs. Thanks to the increasing power in the transient dedicated surveys, the population of TDEs has quickly grown. However, the origin of the diverse emission is still a mystery and different scenarios have been proposed, which predict different observing features. I will present the results from the multi-band monitoring campaign of the transient AT2022wtn, hosted in the nucleus of the less massive galaxy of an active merging pair. AT2022wtn is consistent with a X-ray faint N-strong TDE and shows a number of peculiarities: a 30-days long plateau at maximum luminosity, a corresponding dip in temperature, the development of a double-horned NIII+HeII line profile and indications of strong outflows. Overall, the system can be described by the full disruption of a low-mass star by a $10^6 M_\odot$ SMBH followed by an efficient disk formation and the launch of a quasi-spherical reprocessing envelope of fast expanding outflowing material. The AT2022wtn host galaxy properties suggest that it is in the early stages of the merger, therefore we may be witnessing the initial enhanced rate of TDEs in interacting galaxies before the post-starburst phase. The implications for the discovery of two TDEs in interacting galaxy pairs will be also discussed.

X-ray Spectral Transitions in TeV Blazars

Navaneeth P K
Janusz Gil Institute of Astronomy, University of Zielona Góra, Poland

Blazars represent the most extreme class of active galactic nuclei, characterised by relativistic jets oriented towards Earth. Recent observations have revealed that certain blazars exhibit flux-dependent X-ray spectral transitions that reflect fundamental changes in emission mechanisms. During flaring states, X-ray spectra become characteristically soft as synchrotron radiation dominates, while quiescent states display substantially harder spectra where inverse-Compton processes dominate. Intermediate flux states reveal mixed emission signatures from both components. We present a systematic study of X-ray spectral transitions in the selected TeV-detected blazars: 1ES 1215+303, S5 0716+714, W Comae, 4C +21.35, AP Librae, B2 1420+32, OT 081, 1ES 2344+514, TXS 0506+056, BL Lacertae, OJ 287 and OP 313. We perform detailed timing and spectral analysis of the X-ray data, including fractional variability, cross-correlation analysis, and spectral variability studies. Broadband spectral energy distributions are constructed for different flux states and modelled using a one-zone leptonic model to constrain the physical parameters. This work provides the first comprehensive characterisation of X-ray spectral transitions for a sample of TeV blazars. Our results reveal systematic patterns in spectral evolution that constrain the physical conditions in relativistic jets and provide new insights into the emission mechanisms operating during different activity levels.

Probing the high velocity outflow BALs in quasars using multi-epoch spectroscopy

Aromal Pathayappura
The University of Western Ontario, Canada

We present the results from a South African Large Telescope (SALT) campaign monitoring the time variability of C IV broad absorption lines (BALs) in 64 high-redshift quasars with high-velocity outflows ($v > 15{,}000$ km/s). Our findings show that BAL variability increases over time, with SALT enabling detailed analysis on both short and long timescales. While BAL variability shows no significant correlation with quasar properties like black hole mass or Eddington ratio, a moderate correlation with bolometric luminosity is observed. Detailed photoionization modeling of a few well-monitored sources highlights discrepancies between observations and simple accretion disk-wind models. We also observe sources with extreme high- and low-ionization BAL variability that supports a multi-component outflow model where different components affect each other. Our analysis suggests that these outflows carry substantial mechanical energy, potentially driving significant AGN feedback. Preliminary results from a new sample of high-z quasars with extreme continuum variability will also be presented, including a discussion on emission line variability in their broad line regions based on spectroscopic monitoring.

Hydrogen Column Density Variability in a Sample of Local Compton-Thin AGN

Andrealuna Pizzetti
European Southern Observatory, Chile

We present the multi-epoch analysis of 13 variable, nearby (z less than 0.1), Compton-thin active galactic nuclei (AGN) selected from the 105-month BAT catalog. Analyzing all available archival soft and hard X-ray observations, we investigate the line-of-sight hydrogen column density (NH) variability on timescales ranging from a few days to approximately 20 years. Each source is analyzed by simultaneously modeling the data with three physical torus models, providing tight constraints on torus properties, including the covering factor, the cloud dispersion, and the torus average hydrogen column density. Our final sample includes 27 variable, Compton-thin AGN after implementing another 14 AGN analyzed in our previous work. We find that all sources require either flux or NH variability. Based on the degree of variability, we classify 10/27 as NH Variable, 12/27 as non-variable in NH, and 5/27 as Undetermined. Noticeably, there is no discernible difference between geometrical, intrinsic and accretion properties among the three variability classes, suggesting no intrinsic differences between the NH-variable and non-variable sources within the considered sample. A new comparison with sources with logEdd more than 0.1 will also be presented.

The overdense environment of z∼6 quasars traced with MUSE

Alexandre Pozzi
Université de Genève, Switzerland

Quasars at z>6 are the most extreme objects in the early Universe, hosting supermassive black holes (SMBHs) with masses above 10^8 M sol, less than a billion years after the Big Bang. Theoretical models predict that such rapid SMBH growth occurs in the most overdense environments, e.g. within the most massive halos of the early cosmic web. However, substantial observing campaigns in the optical and near-infrared have so far failed to conclusively detect these overdensities, raising questions about our understanding of early black hole formation. In this talk, I will present the detection of galaxy overdensities around z∼6 quasars uncovered through a systematic search for Lyman-alpha emitters (LAEs) around z>6 quasars using medium-deep MUSE archival observations. With a new sample of 30 quasar fields, this study increases by an order of magnitude the number of fields compared to the literature. We find a lower clustering length of quasars in tension with existing studies using non-LAE as overdensity tracers, either suggesting a lower halo mass for quasars or differential clustering of Lyman-alpha emitters in the ionised environments of z>6 quasars. The latter hypothesis is supported by evidence for a spatial alignment between quasars and their surrounding LAEs which may trace the quasar's ionizing cone. Finally, I will compare our observational results with cosmological simulations in order to shed light on the mechanisms underlying early supermassive black holes growth.

Estimating the mass of Narrow Line Seyfert 1 Galaxies using the Damped Random Walk (DRW) Method

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Indian Institute of Science(IISc), India

Narrow-Line Seyfert 1 galaxies (NLSy1s) are commonly regarded as rapidly accreting, low-mass AGNs, yet uncertainties remain about their true black hole masses, especially for sources with extreme properties. In this study, we analyze ZTF g-band light curves for 1,127 NLSy1s and 1,141 BLSy1s, modeling their variability using a Damped Random Walk (DRW) framework. We employ a multivariate calibration incorporating rest-frame wavelength and Eddington ratio to refine black hole mass estimates derived from the characteristic variability timescale. While the DRW timescale–mass relation alone yields broadly similar average masses across the two populations, the calibrated distributions clearly distinguish NLSy1s as hosting systematically lower-mass black holes, with a median $\log(M_{\rm BH}/M_{\odot}) = 6.44$ for NLSy1s versus 7.19 for BLSy1s. We further find significant inverse correlations between variability amplitude and optical luminosity, Eddington ratio, and Fe II strength (R_{4570}), indicating that higher accretion rates are associated with suppressed long-term variability. These results suggest the lower-mass, high-accretion nature of NLSy1s and highlight the utility of time-domain variability in constraining AGN demographics.

A new black-hole mass scaling relation based on Coronal lines and supported by accretion predictions

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Determining the mass of the supermassive black hole (BH) at the centre of active galactic nuclei (AGN) via reverberation mapping (RM) is time consuming and cannot be applied to large samples of sources. However, methods employing single-epoch spectrum for the same purpose have become very popular due to their convenience but require a well-calibrated relationship. We present a new approach to determine the black hole mass (M_BH) using coronal lines (CLs). To this aim, bona-fide M_BH from RV for 30 AGN and their corresponding integrated emission line fluxes of CLs such as [FeVII] 608.7 nm and [SiVI] 1963 nm normalized to their nearest HI emission, were employed. We found a scaling relation of the form log(M_BH) = 6.40 - 1.99 * log ([SiVI]/Br_gamma), over the M_BH mass interval 10^6-10^8 solar mass, with dispersion 0.47 dex. Under a central source photoionization scenario, the ratio [SiVI]/Br_gamma traces the AGN ionizing continuum. Following on the thin accretion disc approximation and after surveying a basic parameter space for CLs production, we found that a key parameter driving this anti-correlation is the effective temperature of the accretion disc, this being sampled by the CL gas and in line with the thin accretion disc prediction T_disc $\sim$ M_BH$^{-1/4}$. In the light of the copious amount of data generated by the JWST, this new scaling relationship can be applied to large samples of AGN and possibly expanded to other CLs detected in the mid-infrared region.

Host Galaxy properties of highly accreting SMBH in the local Universe

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An open question in extragalactic astronomy is the extent to which Active Galactic Nuclei (AGN) affect the evolution of their host galaxies. Host galaxy properties of AGN, such as star formation rate and stellar mass, are key parameters for studying the role of AGN in galaxy evolution. However, disentangling the infrared emission from AGN and star-forming components is a challenging task that requires comparing advanced spectral energy distribution (SED) models. We present a dedicated study of the star-forming content in the host galaxies of nearby, hard X-ray-selected AGN from the BAT AGN Spectroscopic Survey, based on ancillary multi-wavelength data and state-of-the-art SED modeling. The AGN sample spans a wide range of bolometric luminosities, black hole masses, Eddington ratios, and levels of obscuration. This allows us to investigate the host galaxy properties of highly accreting SMBHs in comparison with those of AGN accreting at lower rates.

The rise and evolution of first quasars

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The coexistence of rapid supermassive black hole (SMBH) growth and intense star formation in the Epoch of Reionization (EoR, z>6) poses a fundamental challenge to current galaxy formation models. By combining ALMA/NOEMA observations with new JWST imaging, we are now able to explore the host galaxies and surrounding environments of highly accreting SMBHs with unprecedented detail. In a recent publication, we analyzed millimeter properties of 25 quasars at z>6, including the complete population at z>7, finding dust-rich (Mdust∼1E8 Msun), gas-poor (Mgas<∼1E10 Msun) systems with some of the highest star formation efficiencies known. Comparing the population of EoR quasars with AGN/quasar at later epochs, we confirmed a solid link between rapid star formation and luminous quasar activity. The observed relatively low depletion times suggest that the growth of the host of EoR quasars will be quenched efficiently in few hundred Myr. Recently, thanks to JWST sensitivity, we can track the host evolution by measuring stellar mass (M*∼1E9-10 Msun) and metal enrichment of the ISM and CGM. First results indicate that AGN-driven feedback plays a key role in enriching the CGM with metals, even at early cosmic times. A comparison with predictions from the GAEA semi-analytic model suggests that AGN feedback dominate over stellar one in suppressing star formation by depleting the gas reservoir, while mergers help sustain SMBH and host growth via gas inflows.

Mature jetted black holes in a young Universe: do they have a super-Eddington history?

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The formation and evolution of the first supermassive black holes (SMBHs) have been put in the spotlight after the discovery of few hundreds extremely massive quasars at high redshift. An interesting twist in our understanding of the matter was introduced by the discovery of an unusual number of jetted sources: X-ray observations of blazars (i.e. AGN with jets aligned to our LoS) at z>4 prove that the most massive active black holes are preferentially hosted in jetted quasars in the first Gigayear from the Big Bang. Jets might thus play a crucial role in fast assembling and accreting matter onto SMBHs. Weirdly, the z>4 blazar population does not show common signs of super-critical accretion. I will first present our current knowledge about z>4 blazars, that trace a comprehensive view on jet, accretion and mass features of the M> 10^9Msun jetted quasars population. Then I will explore the possibility that sustained super-Eddington episodes are key to launching relativistic jets. In Alzati et al. (2025) we propose this possibility to justify the features of the highest-z persistent Fermi blazar, that despite its large mass and fully developed relativistic jet host a very slowly accreting SMBH. Jets might thus be the most efficient tracers of past super-Eddington accretion, and their earliest stages might be our best bet to catch in the act early super-critical evolution.

Probing the Growth of Supermassive Black Holes through Dual AGN at Cosmic Noon

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A large population of AGN pairs residing in the same galaxy—the so-called dual AGN—is predicted to exist at redshifts z > 0.5. These systems are the progenitors of black hole mergers, making their census and properties fundamental for predicting the gravitational wave background and the event rates accessible to PTA experiments and the future LISA mission. Until recently, only a handful of dual AGN at sub-arcsecond separations had been identified. In this talk, I will present the first statistically significant sample of such systems, selected via two complementary techniques: the innovative Gaia Multi-Peak (GMP) method and high-sensitivity photometry from Euclid. These have revealed hundreds of candidates with separations between 0.15" and 0.8" (∼kpc at z > 0.5). Follow-up observations are critical to confirm their dual AGN nature and distinguish them from gravitational lensing. I will present spatially resolved spectroscopy of ∼50 systems at cosmic noon, obtained with AO-assisted instruments such as Keck, VLT, and LBT. Based on this unique sample, I will discuss the first detailed characterization of dual AGN properties—luminosity and mass functions, separation distributions, redshift evolution, and their fraction among the total AGN population. These results offer new insights into the co-evolution of SMBHs and their hosts, and provide a rare observational test for cosmological simulations and theoretical models of black hole accretion and merging history.

Time-evolving diagnostic of the ionized absorbers in the Narrow-Line Seyfert 1 galaxy NGC 4051

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We present detailed time-resolved X-ray spectroscopy of the Narrow-Line Seyfert 1 galaxy NGC 4051, using both the low- and high-resolution cameras aboard XMM-Newton and NuSTAR. Ionized absorbers are present in more than half the UV and X-ray spectra of local AGN, although their origin and location are seldom measured with accuracy. We find evidence of multiple layers of ionized absorbers for which past observations established non-equilibrium conditions (e.g. Krongold et al 2007). The identification of three absorbers with high energy resolution spectra, with outflow velocities between 500 km/s and 6000 km/s, represents the most detailed picture of the X-ray ionized outflows in this AGN so far. Moreover, time-resolved spectroscopy is also performed, allowing the study of how the three absorbers vary their ionization state in time. Indeed, a diagnostic based on the variation of the ionization parameter compared to the ionization and recombination timescales and the usage of the non-equilibrium model Time Evolving Photo Ionisation Device (TEPID, Luminari et al., 2024), is able to constrain the location of the outflows with unprecedented accuracy, ranging from a few to a dozen light days from the central black hole. This work will open the way to detailed studies of variable absorbers in many sources, with future X-ray microcalorimeter observations, shedding light on the role of small-scale winds in the big picture of AGN feedback on the host galaxy.

Evidence for Cold Outflows at z$\sim$6

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Observations reveal a strong correlation between supermassive black hole (SMBH) masses and their host galaxy properties, suggesting a fundamental connection regulated by feedback. The similar cosmic evolution of SMBH accretion and star formation further supports this link. At z$\gtrsim$6, quasars host SMBHs that are significantly more massive than expected, indicating rapid early growth before settling into local scaling relations. Theoretical models suggest that black hole growth slows around z$\sim$6, likely due to outflows, which may contribute to the emergence of massive, quiescent galaxies by z$\sim$2-4. However, direct observational evidence for such outflows remains inconclusive. At z$\gtrsim$6, the [CII] 158 μm fine-structure line is commonly used to trace galactic dynamics and potential feedback effects, though the presence of broad wings, indicative of outflows, remains debated. This study investigates outflows in quasars from the XQR30 sample using archival ALMA [CII] data. Broad absorption features observed with VLT/X-shooter, which trace ionized outflows, appear in $\sim$50% of the sample. Some quasars exhibit extreme outflow velocities, increasing the probability of detecting cold gas outflows in [CII]. Initial analysis reveals the need for a broad component in only four sources. Stacking the spectra suggests a broad component is required to fit the stacked spectrum best. This study also explores the presence of extended [CII] halos as potential indicators of past feedback episodes.

Probing AGN Jet Feedback Across Cosmic Time: A Simulation Perspective

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Active Galactic Nuclei (AGN) significantly impacts galaxy evolution through feedback driven by relativistic jets. At higher redshifts, these jets are thought to produce strong X-ray emissions via inverse Compton scattering of Cosmic Microwave Background (IC/CMB) photons. As CMB photon density rises with redshift, this process becomes more prominent and may explain enhanced X-ray output from AGN jets in the early universe. Understanding this effect is key to revealing how AGN influences their surroundings and shapes galactic evolution. We explore IC/CMB's role in boosting X-ray emission in jet lobes and examine its variation with redshift. Using the PLUTO code's 3D relativistic magnetohydrodynamic (RMHD) module in a hybrid Eulerian-Lagrangian setup, we conducted simulations that include a new IC/CMB radiation module to study redshift-dependent CMB effects. Our results show that IC/CMB-induced X-rays become notable only beyond $\sim$5 kpc from the AGN core, supporting a partial IC/CMB model. We also observe spectral peaks in simulated radio emissions below 500 MHz, resembling those of Compact Steep Spectrum (CSS) sources. This study links multiwavelength AGN jet observations across redshifts and provides a simulation-based approach to interpret correlation between X-ray and radio data from different telescopes.

Expedited growth of massive black holes fed by repeated tidal disruption of stars

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In this talk, we investigate dense nuclear clusters as the environment for massive black hole (MBH, supermassive or intermediate-mass) growth due to frequent dynamical interactions between stars the MBH. Once formed, the MBH's gravitational influence enables the accretion of surrounding field stars through a high rate of tidal disruption events, resulting in the buildup of a dense, optically thick gaseous disk or envelope. We find that the mass feeding rate onto the IMBH is further enhanced by tidal capture and interactions between stars and the accretion disk, potentially sustaining super-Eddington accretion, especially for IMBHs. These results suggest that dense nuclear clusters can support both the formation and substantial growth of MBHs. We also discuss how this scenario could be related to recent JWST observations of high-redshift "little red dots" (LRDs) and the early phase of SMBH growth.

Characterising Obscured AGN and Their Hosts at $1 < z < 10$ with JWST and BEAGLE-AGN

Maddie Silcock
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Recent JWST observations have unveiled a growing population of high-redshift AGN, including Type-II candidates that offer unique insights into early obscured supermassive black hole

(SMBH) evolution. In this talk, I will present a spectrophotometric analysis of 41 such AGN candidates spanning redshift 1-10 (Silcock et al. in prep), identified in JADES Ultra-Deep and Deep tiers (Scholtz et al. 2025). Characterising these sources enables us to track AGN properties across cosmic time and probe obscured phases of accretion during the early Universe. We use BEAGLE-AGN (Vidal-García & Plat et al. 2024), an SED fitting framework that simultaneously models stellar, nebular and AGN NLR contributions to galaxy spectra. This provides constraints on AGN accretion disk luminosity, ionising photon production efficiency, stellar mass and star-forming region/NLR gas-phase metallicities, to name a few. These constraints allow us to map the evolution of obscured AGN/host properties, including populating the high-redshift AGN mass-metallicity plane whilst splitting the HII and NLR contributions to the emission lines. We also analyse these objects for non-standard elemental abundances (e.g. Silcock et al. 2024), which has implications for our understanding of chemical enrichment pathways in early Universe AGN. The methodology and findings of this work offer a crucial addition to the discussion of early supermassive black hole evolution by leveraging the characterisation of obscured SMBH.

Unravelling Changing-Look AGN

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Accretion discs around supermassive black holes are mostly considered as equilibrium systems. The Changing-Look (CLAGN) phenomenon, however, points to state changes on remarkably short time scales and may result from initially small variations around a state boundary. Thus there is an opportunity to study the physics of alternative states of AGN discs in detail. Current CLAGN data sets are sparse, but the all-sky coverage of LSST will allow identification and spectroscopic tracking of AGN as they undergo type changes. It is well established that type changes are much more prevalent in low luminosity (Seyfert) AGN than in quasars. To prepare for LSST monitoring, we have identified a large optically-complete Southern sample of both Seyfert I and II galaxies at low redshifts. Multi-wavelength data has been used to characterise different emission components in the sample. We will present the sample properties, including current statistics on their long-term state changes. Further details of the LSST-supported experiment will be described.

Discovery of a luminous Little Red Dot at z$\sim$10 in COSMOS-Web based on NIRCam-MIRI selection

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Deep IR observations by JWST have discovered a new population of high-redshift compact objects known as "little red dots" (LRDs) with a characteristic V-shape SED with the trough around the Balmer limit. Based on the detection of broad Balmer emission lines, previous studies have suggested that LRDs are low-luminosity AGNs, possibly linked to super-Eddington accretion shortly after seed BH formation. Previous photometric LRD selections have used NIRCam photometry, making them susceptible to contamination by low-redshift interlopers or z$\sim$10 galaxies with a stellar-origin Balmer break other than z$\sim$10 LRDs. In this study, we propose a new color selection technique for identifying LRDs at z$\sim$10, utilizing both NIRCam and MIRI photometry to extend the redshift frontier of LRD studies. Applying this method to COSMOS-Web, the largest NIRCam-MIRI joint survey, we find one solid candidate with a compact morphology, a clear F115W dropout, and a V-shape SED. This candidate with the photometric redshift of $\sim$10.5 represents one of the most distant SMBHs so far, potentially representing the era just after seed BH formation. In the talk, we will present the first constraints on the luminosity function of LRDs at z$\sim$10 and discuss the implications of this discovery for our understanding of SMBH evolution in the early Universe.

A long-term look into variability and duty cycle of gamma-ray narrow-line Seyfert 1s with Swift

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INAF-OAB, Italy

Gamma-ray narrow-line Seyfert 1 galaxies (gNLS1s) are now well-established as part of the family of jetted active galactic nuclei. After their discovery in 2009, their number has steadily increased, but they are still usually observed as a response to flares in the gamma-ray energy band. Therefore, in order to investigate the long-term behaviour of such kind of sources, we performed year-long Swift monitoring campaigns with weekly observations on four prominent gNLS1s which include the best candidates for detection by the Cherenkov Telescope Array Observatory, namely SBS 0846+513, PKS 1502+036, FBQS J1644.9+2619, and PMN J0948+0022 (with the latter recently being re-classified as an intermediate Seyfert, and hence providing a control case). Our campaigns offer, for the first time, a systematic study of gNLS1s without the bias of ToO observations triggered from gamma-ray flares, thus providing an investigation of their intrinsic properties. Our Bayesian blocks analysis of the long-term monitoring light-curves yields an estimate not only of variability but also the duty cycle of the gNLS1 and the expected number of flares per year.

The interplay among accretion power, ionizing continuum, and outflows in quasars at Cosmic noon

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Optical and UV spectroscopy of very powerful quasars offers invaluable insights into both accretion properties and sub-pc to kpc-scale ionized gas kinematics of objects hosting the most extreme SMBHs. Low-ionization lines such as Hβ are commonly used as tracers of systemic redshift and black hole (BH) mass, due to their relatively symmetric profiles, while [OIII] emission line is usually adopted to trace outflows at galaxy-wide scales. High-ionization lines like C IV often exhibit significant blueshifts, asymmetries, and powerful outflows in the circumnuclear region—sometimes accompanied by broad absorption features reaching velocities up to $\sim$0.2c. The faint He II emission line emerges as a sensitive indicator of the ionizing continuum and coronal processes, showing a strong correlation with the properties of C IV. Our systematic analysis of a large sample of highly accreting QSOs at cosmic noon indicates that single-epoch virial BH mass estimates based on Balmer lines can significantly overestimate the mass, suggesting that a substantial fraction of these sources are accreting well above the Eddington limit. I will review the diversity of the nuclear spectral signatures in these QSOs as a function of AGN properties, such as bolometric luminosity, BH mass, Eddington ratio, and optical-to-X-ray spectral slope, aiming to link nuclear and galaxy-wide scales and shed light on the significant impact that highly accreting SMBHs may have on both AGN regions and their host galaxies.

The impact of ISM structure on multiphase AGN outflows

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Active galactic nuclei (AGN) drive powerful, multiphase outflows into their host galaxies which are expected to play a key role in galaxy evolution. However, exactly how small-scale accretion disc winds couple to the ISM to drive kiloparsec-scale outflows remains an open question. In this talk, I will present our AGN in Clumpy DisCs (ACDC) simulations which feature a physically-motivated AGN wind model embedded in an idealised galaxy disc with a resolved ISM, manually distributed in a clumpy substructure. We find that the hot wind causes the cold ISM clumps to fragment and become entrained in the outflow as small cloudlets. This leads to an outflow that differs significantly from commonly-considered shell-like morphologies, which has important implications for observational studies seeking to characterise outflows and infer their impact on the hot galaxy. I will discuss the impact the clumpy ISM has on outflow scaling relations, and also present predictions for X-ray emission caused by these wind-ISM interactions that could be detected with telescopes such as Chandra or AXIS.

Identifying tidal disruption events among radio transient galaxies

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Modern optical-UV time-domain surveys have led to the discovery of two types of variable accretion onto supermassive black holes (SMBHs), both of which can result in the formation of radio jets: the tidal disruption of a passing star by a dormant SMBH leading to transient accretion of stellar debris, and a class of “changing-state” AGNs characterized by spectral state transitions, which can be explained by intrinsic changes in accretion properties. Using modern radio time-domain surveys, such as the ongoing Very Large Array Sky Survey (VLASS), we discovered a group of objects that appeared as new radio sources after two decades of absence. These objects are transient phenomena relative to previous radio surveys and, following a significant increase in radio luminosity, have been classified as radio-loud. We suggest that, for the vast majority of our sources, the radio transient emission event is likely caused by intrinsic changes in accretion properties, similar to what is observed in changing-state AGNs. However, we cannot rule out the possibility that a few of our sources may belong to the rare class of radio-emitting tidal disruption events (TDEs). We present a comprehensive multi-epoch and multi-wavelength study of these objects. Additionally, we propose a simple diagnostic diagram that could serve as a useful tool for distinguishing between radio transients caused by TDEs and those originating from intrinsic AGN variability.

Intranight Optical Variability of IMBH candidates

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Using the ongoing Zwicky Transient Facility (ZTF) survey, we investigated the intra-night optical variability (INOV) of intermediate-mass black hole candidates (IMBHs). Among 953 selected IMBH candidates with broad Ha component and ZTF photometry monitoring, we focus on 76 candidates with logMBH<6, r<19.0 and 203 sessions of intra-night data, each epoch including more than 20 data points with at least 3 hours. By excluding the influence of observational seeing effect and host galaxy light diluting the subtle AGN variability, we set strict constraints on the seeing variation of the intra-night session and obtained each session's light curve by carrying out the aperture-photometry on the ZTF differential images. We find that ∼10% of the sessions show INOV based on four statistical parameters describing the INOV variability. The possible nature is briefly discussed. The candidates provide robust candidates for future IMBH reverberation mapping project, enhancing the possibility of detecting variability and lag in future IMBH reverberation campaigns.

POSTERS

Collision of clouds from the broad-line region in super-Eddington supermassive black holes

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We present results from hydrodynamic, relativistic simulations of the collision of clouds from the broad-line region. In our model, the clouds orbit a super-Eddington supermassive black hole (SMBH). The clouds move at supersonic speeds through the dense wind launched from the SMBH's accretion disk. Collision between the clouds can produce strong electromagnetic flares that reveal some properties such as their mass, volume, and speed. We analyze spherical and fractal clouds colliding with different impact factors. Our results provide insight into this unexplored phenomenon.

Exploring Stellar Populations and Nuclear Activity in iMaNGA Sample on IllustrisTNG Simulations

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Studying galaxies through multi-wavelength spectroscopy helps us understand their structure, makeup, and how they evolve. Observations show that galaxies with active galactic nuclei (AGN) tend to have fewer old stars and more young to intermediate-aged stars (100 Myr to 2 Gyr) than those without AGN. We're investigating if this pattern also appears in hydrodynamical simulations. We're using the iMaNGA sample (Nanni et al. 2022) from the IllustrisTNG simulation, which is designed to mirror galaxies seen in the MaNGA spectroscopic survey. To analyze the stellar populations in these simulated galaxies, we're applying the Urutau software (Riffel et al. 2023) to 1511 iMaNGA galaxy cubes. Using Eddington ratios, we've identified simulated active and non-active galaxies. We then created a control sample of non-active galaxies matched in redshift, stellar mass, and morphology. Our goal is to build radial profiles of stellar population contributions, directly comparing the active and non-active simulated galaxies. Here, we present preliminary results from these simulations and compare them with actual galaxies from the MaNGA catalog. This comparison will help us interpret the similarities and differences between real and simulated galaxies, especially how nuclear activity influences star formation in AGN-hosting systems.

Jet-mode feedback in NGC 5972: insights from resolved MUSE, GMRT and VLA observations

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We present a comprehensive analysis of the ionized gas in the kpc-scale extended emission line region (EELR) of NGC5972, a "Voorwerp galaxy". This class of galaxies are known for its distinctive strong [OIII] emissions and provides a unique opportunity to explore the role of AGN feedback in shaping large-scale EELR. Our aim is to study AGN-driven feedback, particularly jet- mode feedback in NGC5972, to quantify the contributions of AGN photoionization vs shock ionization in the ISM. This galaxy is particularly well-suited for such an investigation due to the spatial alignment of the EELR with the radio jet. Although AGN photoionization is often considered the primary ionization mechanism in Voorwerp galaxies, recent studies (e.g., NGC4388, Teacup quasar) emphasize the significant role of radio jets. For NGC5972, our findings reveal that while AGN photoionization contributes to the ionization of the EELR, the radio jet plays a crucial role in driving outflows and generating shock emissions on a larger scale perpendicular to the jet. Thus, we propose a combined shock+photoionization model as the most plausible ionization model, which effectively accounts for all the multi-wavelength observations. We have used optical integral field unit (IFU) archival data from VLT MUSE instrument to study the stellar and ionized gas kinematics, complimented with VLA and GMRT radio data to understand the interaction between radio emission features that trace the jet, and the ionized gas.

Correcting Black Hole Masses Biased by Size Inertia in Broad Line Regions

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Estimating supermassive black hole masses in AGN mostly relies on the virial method, which uses the radius-luminosity (R-L) relation to determine the radius of the broad line region (BLR). The R-L relation heavily depends on the assumption that the BLR is virialised. High-cadence monitoring of NGC 5548 and a volume-complete two-epoch Southern Sky AGN sample at $z<0.1$ have revealed significant optical luminosity changes over 15-20 years but did not show the expected virial anti-correlated change in the broad H-beta line width, indicating the BLR is not virially breathing on decadal timescales. Single-epoch masses from L5100 and broad H-beta R-L relations exhibit time-variations with a scatter of $\sim$0.5 dex over 20 years. The deviation from the mean depends on the broad H-beta to narrow [OIII] luminosity ratio. Comparing reverberation mapping and single-epoch mass estimates from different luminosity proxies using the R-L relation showed that mass estimates derived from the [OIII] luminosity and the broad H-beta FWHM have the lowest scatter. The absence of virial breathing implies that BLR sizes do not correlate with short-term luminosity variations. Instead, narrow-line AGN emission, which conveys accretion rates averaged over centuries, serves as a more reliable proxy for the instantaneous BLR radius.

A panchromatic view of IR quasars: revealing their role in evolutionary scenarios

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Evolutionary scenarios predict that obscured quasars play a key role in the evolution of galaxies; however, this role has not yet been fully understood since quasar samples are typically biased against obscured systems. We select and constrain the AGN and host galaxy properties of a complete and unbiased sample of 578 infrared (IR) quasars (LAGN,IR>1e45erg/s) at z<3, using spectral and photometric data from X-rays to radio wavelengths. We find that 61% IR quasars are obscured (55% are X-ray undetected) and identify fundamental differences in the average properties of obscured and unobscured quasars: 1) obscured quasars have star-formation rates ≈3 times higher, driven by a larger population of extreme starburst host galaxies, and 2) obscured quasars have stronger radio emission, potentially due to the interaction of jets or winds with a higher opacity circumnuclear medium (i.e., quasar "feedback"). We find that many of the obscured quasars are sub-mm galaxies and show that part of the obscuration could be due to compact dusty starbursts. Our results suggest that obscured IR quasars are an earlier phase in the evolution of galaxies.

ALMA observations of the corona revealing intrinsic luminosities of obscured AGN

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It is slowly being accepted that mm-waves, say between 30 – 300 GHz, are the best tool with which to observe the innermost regions of active galaxies in the immediate vicinity of the supermassive black hole (SMBH), and that this emission likely arises from a corona associated also with the X-ray source. The talk will describe the history and recent evidence for this conjecture based on spectral and timing observations with ALMA. One powerful result arising from this association is the ability to access obscured AGN, a large fraction of which are nearly Compton thick (column density of $N_H > 10^{24}$ cm^{-2}), thus making their total intrinsic luminosity uncertain and highly model-dependent. We will demonstrate how ALMA, through established correlations between the mm and X-rays can provide a new method to obtain intrinsic AGN luminosities. The high sensitivity of ALMA will be particularly useful for this method when applied to the high-z AGN recently discovered by JWST.

Quasi-periodic Jet Precession in the Quasar NRAO 530

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Jets in active galactic nuclei (AGN) can undergo changes in direction over time, often linked to physical processes near their central supermassive black holes. In this study, we analyze the parsec-scale jet of the quasar NRAO 530 using 160 epochs of VLBI (Very Long Baseline Interferometry) observations at 43 GHz, covering the period from 2007 to 2024. We measured the inner jet apparent position angle (PA) in each epoch and found a quasi-sinusoidal variation with a period of approximately 6.6 years. This period coincides with previously reported timescales of flux variability, suggesting a common origin possibly driven by varying Doppler boosting due to the jet precession. Among the mechanisms that could explain this behavior, we find that Lense-Thirring precession of the tilted accretion disk is the most plausible. By combining the observed precession period with luminosity-based constraints, we narrow down the range of the parameters of the black hole and accretion disk system, including the black hole spin and the precessing disk size.

Unveiling blazar synchrotron emission: multiwavelength polarimetric study of HSP and LSP populations

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Polarimetry offers a powerful window into the physical conditions and particle acceleration processes within blazar jets. In this study, we investigate the multiwavelength polarimetric behaviour of High Synchrotron Peaked (HSP) and Low Synchrotron Peaked (LSP) blazars to explore differences in their emission mechanisms and magnetic field structure near the acceleration region. We take advantage of several X-ray polarisation observations of HSP by the Imaging X-ray Polarimetry Explorer, including four new observations of Mrk501, and optical polarisation observations of LSP from RoboPol and other monitoring programs. We find that the polarisation degree (PD) of HSPs in X-rays is systematically higher than in the optical and mm-radio bands, consistent with earlier IXPE findings. Moreover, the electric vector position angles (PA) in the X-rays are predominantly aligned with the jet axis, with most measurements showing minimal offset within uncertainties. When comparing the offset of the polarisation angle from the jet axis between the LSP and HSP populations—measured in optical and X-rays respectively—we find a consistent distribution. This points toward a shared magnetic field structure near the particle acceleration region and lends strong support to the emerging picture of energy-stratified acceleration followed by radiative energy loss in blazar jets.

ESO137-G034: Unveiling Coronal Structures and Feedback Mechanisms

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Active galactic nuclei (AGN) are among the brightest objects in the Universe, emitting across the entire electromagnetic spectrum. The coupling of radiation from the central source with the interstellar medium (ISM) generates feedback, capable of producing turbulence, outflows, and coronal line emission. This study focuses on the galaxy ESO137-G034, ideal for feedback studies due to a jet in strong interaction with the ISM. [O III] observations with HST reveal a conical structure and a ‘Z’-shaped formation, while ATCA data show three radio lobes aligned with emitting regions, suggesting mechanical feedback. The objectives of this study include: characterizing the ionized gas morphology, quantifying nuclear and peripheral contributions, and performing multiband comparisons (near and mid-infrared) to map coronal gas. Data were obtained through integral field spectroscopy with the SINFONI (VLT) and MIRI-MRS (JWST). The analysis revealed, for the first time, the nucleus position, and MIRI-MRS maps indicate, for the first time, [Ne V] extensions up to 1.1 kpc, with coronal emission lobes and filaments. [Si VI] emission shows a nuclear contribution of $\sim$1%, highlighting shocks as an additional energy mechanism. We conclude that ESO137-G034 exhibits significant feedback, with filamentary coronal structures and lobes surpassing the central region in flux, making it a peculiar case in the literature.

Merger-AGN-SFR connection in dynamically close galaxy pairs

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Models on the proposed evolutionary sequence of galaxies suggest that as part of a galaxy's life cycle, they undergo interactions and mergers which increase AGN activity and star formation, then later suppression. However, this has not been observationally well supported. In this work, we aim to go a step further in testing the connection between galaxy mergers, AGN activity, and star formation in close pairs using unWISE data at low redshift ($z<0.2$). We selected pairs at six projected distance separations (0-20, 20-50, 50-100, 100-250, 250-500, 500-1000 kpc) and two velocity differences (0-500, and 500-1000 km/s), then measuring the X-ray & radio luminosities, W1-W2 colors (indicating AGN activity), NUV-r colors (indicating star formation), and optical emission lines in BPT indicating both AGN activity and star formation. We compare the effect of distance and velocity separations on nuclear activity and star formation. Results indicate no significant increase in X-ray, radio, infrared, and optical selected AGN as pair separation decreases, while we find a slight suppression of star formation as pair separation decreases. Our findings also confirm some previous suggestions that AGN are mostly hosted by massive structures at higher redshifts compared to smaller structures at lower redshifts. We later compared these results to that of the one obtained from the Illustris TNG300 simulation, we obtained similar results, concluding that galaxy mergers may not trigger AGNs.

Unveiling faint X-ray AGN populations in the NewAthena era: insights from cosmological simulations

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Recent observations expanded our understanding of galaxy formation and evolution, yet key challenges persist in the X-ray regime, crucial for studying Active Galactic Nuclei (AGN). These limitations drive the development of next-generation observatories such as ESA's NewAthena. Now in phase B (preliminary design), the mission requires extensive testing to ensure compliance with its scientific goals, particularly given the uncertainties surrounding high redshift AGN. This work leverages the IllustrisTNG cosmological simulation to build an X-ray AGN mock catalogue and assess the performance of NewAthena's WFI. We created a Super Massive Black Hole (SMBH) light cone, spanning 10 deg2, with corrections to account for the limited resolution of the simulation and X-ray properties derived in post-processing. The resulting catalogue reveals a 5* overabundance of faint AGN compared to current X-ray

constraints, an inconsistency potentially resolved by invoking a higher Compton-thick (CTK) fraction and intrinsic X-ray weakness, as suggested by recent JWST findings. An end-to-end survey simulation using SIXTE predicts 250000 AGN detections, including 20,000 at $z > 3$ and 35 in the Epoch of Reionization ($z > 6$); notably, only AGN with LX > 43.5 erg/s are detectable at $z > 6$. The analysis also forecasts a significant population of detectable CTK AGN, even beyond $z > 4$. These findings suggest X-ray observations will, for the first time, probe a significant AGN population in the EoR.

Optical follow-up of a sample of gamma-ray emitting jetted AGN

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The reclassification of approximately 3000 extragalactic gamma-ray sources from the Fourth Fermi LAT Catalog led to an increased number of identified gamma-ray emitting Seyfert galaxies, including Narrow-Line Seyfert 1 (NLS1) galaxies, misaligned active galactic nuclei (AGN), changing-look AGN, and several ambiguous objects (Foschini et al. 2022). To confirm or refute these new classifications and resolve the ambiguities, we obtained new high-quality optical spectra using GranTeCan/OSIRIS and ESO/VLT UT1/FORS2. From the analysis of these spectra, we identified 6 NLS1 galaxies, 6 intermediate Seyfert (IS) galaxies, and one ambiguous case lying between NLS1 and IS classifications. This reclassification contributes to our understanding of gamma-ray emitting AGN and, in particular, challenges the traditional view that only AGN hosting very massive black holes are capable of launching powerful relativistic jets.

X-Ray spectral properties and soft excess of highly accreting quasars

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We present a quantitative and detailed Bayesian analysis of the X-ray spectral properties of a sample of 207 type-1 AGN along the quasar main sequence, with a particular focus on highly accreting quasars. We analysed XMM-Newton spectra in the 0.3–10 keV range, paying special attention to the presence of a soft excess in the 0.3–2 keV band. Our analysis reveals a statistically significant difference between high- and low-accreting sources in the 2–10keV rest-frame band. Higher accretors exhibit a considerably steeper power-law profile than sources with a low Eddington ratio. This establishes a relationship between the X-ray hard photon index and the quasar accretion rate. The result found in the hard band becomes more significant when the full spectral range and soft emission are considered. A clear difference in soft excess strength is observed between low- and high-accreting sources. The results of the black-body-to-power-law luminosity ratio, Lbb/Lpl, in the 0.5–2 keV range indicate that the soft excess is significant for extreme accretors. Most sources in which black-body luminosity dominates (Lbb/Lpl>0.5) are A2–A4 in the in the Eigenvector 1 main sequence, while the lowest values correspond to low-accreting quasars. We also identify a correlation between the strength of the optical FeII and the X-ray photon index, with a clear tendency for the index to increase as the FeII strengthens.

NLS1 accretion: using emission lines in new ways

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Narrow-line Seyfert 1 (NLS1) galaxies are a puzzling class of active galactic nuclei (AGN), whose peculiar multi wavelength features have always sparked debate on their nature and accretion regime. Low black hole masses, high luminosities, permitted emission lines with FWHM $<$ 2000 km/s, combined with steep X-ray spectra and rapid variability, suggest accretion rates exceeding the Eddington limit. Jetted NLS1s have gathered attention, being sometimes suggested as early evolutionary stages of jetted Type 1 AGN. They might thus provide crucial insights on the early connection between (possibly super-critical) accretion and jet onset. In this study, we focus on gamma-ray NLS1s, hosting jets most likely oriented along our LoS and thus providing a privileged point of view on their central engine. We studied their optical spectra with specific focus on their emission line intensity and relative fluxes, finding significant deviations with respect to the average Type 1 AGN behaviour. Is this linked to a super-Eddington accretion regime? Whether these emission line ratios are due to outflows induced by super-critical regimes, or instead they trace an ionising spectrum not consistent with standard accretion, they are key to understand NLS1 intrinsic nature. To understand which is the case, we focus on gamma-ray NLS1 accretion regime by tackling the issue with two independent approaches: direct accretion emission SED modeling and constraining the ionising potential via indirect tracers.

Exploring Extended Narrow Line Regions in Type 2 AGNs with Magellan IFU Spectroscopy

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Extended Narrow Line Regions (ENLRs) offer a powerful probe of the interaction between active galactic nuclei (AGNs) and their host galaxies, tracing the influence of accreting supermassive black holes (SMBHs) out to kiloparsec scales. In this pilot study, we use integral field spectroscopy with the ROSIE-IFU on the Magellan telescopes to investigate the morphology, ionization structure, and gas kinematics of ENLRs in a sample of optically selected Type 2 AGNs. The obscured nature of these systems enables a relatively unobstructed view of the extended ionized gas, minimizing contamination from the bright AGN core. ENLRs not only reflect ongoing AGN activity but may also preserve signatures of past accretion episodes, offering insights into the temporal variability of SMBH fueling. Our analysis aims to characterize the physical conditions and driving mechanisms behind ENLRs and help with the design of future, larger-scale surveys to be conducted with additional instruments at Magellan.

The jetted NLS1 1H 0323+342: the Rosetta stone for the accretion-ejection in AGN

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1H 0323+342 is the nearest gamma-ray narrow-line Seyfert 1 galaxy (z=0.063). Its X-ray spectrum (0.3-10 keV) is characterized by significant spectral variability observed by many authors, with a backbone with photon index $\sim$2 occasionally superimposed by a hard tail. This spectral variability has been interpreted as the interplay between the X-ray corona and the relativistic jet. The X-ray fluxes in the 0.3-10 keV energy band are generally around 10^{-11} erg/cm2/s, making it easier to get sufficient statistics even with short exposures. Here I present a reanalysis of all the available X-ray observations with Swift (176 obs), XMM-Newton (7 obs), Chandra (1 obs), and Suzaku (2 obs) performed between 2006 and 2024. Possible interpretations are proposed and discussed.

Spherical accretion onto non-singular and bounce spacetimes

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We investigate spherical accretion onto non-singular spacetimes using analytic and semi-analytic techniques to reveal how regularity parameters reshape both Bondi and Novikov-Thorne accretion. First, we revisit steady, radial inflow onto a family of spherically symmetric regular black holes (RBHs): Hayward, Bardeen, Dymnikova, and Fan-Wang. By modeling the ambient medium as either a constant-pressure fluid or an exponential density profilFe, we derive the expressions for the sonic radius, mass accretion rate, and luminosity. We find that RBH geometries amplify the accretion rate compared to Schwarzschild geometries, and that RBHs achieve higher luminosities in the Novikov-Thorne thin-disk framework, independent of the chosen fluid model. Next, we extend the Bondi analysis to the Simpson-Visser metric, which interpolates between black hole and wormhole regimes through a bounce scale l. For both barotropic and exponential-profile fluids, we identify sonic points and compute accretion rates as functions of l. We show that the near-horizon regions are modestly l-dependent while the behavior of the accretion rates exhibits different trends depending on the fluid equation of state. This analysis demonstrates that regularity scales, such as topological charges in Bardeen-type solutions or the Simpson-Visser bounce length, leave observable signatures on accretion dynamics and may help to identify deviations from classical black hole models.

Giant-amplitude variability of radio-quiet and radio-loud AGN: probing an extreme accretion regime

Stefanie Komossa
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The extremes of variability offer valuable new insights into the drivers and physics of AGN. Here, we present the most recent results from our ongoing long-term timing and MWL spectroscopy campaigns on some of the most highly variable, best-studied AGN known to date, including transient AGN like IC 3599 and other changing-look AGN, and exceptional blazar outbursts like that of 1ES 1959+650 discovered by SVOM and followed up with Swift. Results are used to gain insights into the underlying variability mechanisms including accretion disk and BLR physics. Notable differences are seen in the optical spectral response to giant outbursts, implying different intrinsic mechanisms at work.

Cosmic Energy Engines: Exploring FRBs, AGNs, and Feedback Processes Behind Galaxy Formation and the

Rohit Kumar
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This poster attempts to explain how energy is created and spreads across the universe, and how it affects galactic environments, through three major astrophysical topics: FRBs, AGN, and Feedback and the Missing Baryons. We start with fast radio bursts (FRBs) – brief, bright flashes of radio waves from space. By studying data from CHIME and other sources, we learn what causes FRBs to form, what types there are, where and how they are produced, and how they affect our galaxies and their shape. Next, we examine active galactic nuclei (AGN), which are powered by supermassive black holes. We'll also look at what AGN look like and behave in the EM spectrum, and what happens inside an AGN that we can understand from the EM radiation. Like FRBs, AGNs are powered by compact objects such as SMBHs. Some AGNs also have jets. In this poster, we will discuss some physical parameters related to AGN such as black hole mass, jet presence, and orientation. Finally, we look at computer simulations that show how the matter and energy emitted from FRBs and AGNs affect star formation rates and how supernovae and AGN feedback affect the matter (baryons) in galaxies. This poster will also explain why we do not see all the matter we expect and help us find the missing baryons. We will see some mathematical formulas. All three of these things can also explain how these small or huge cosmic objects emit energy that shapes galaxies and the universe.

Broadband X-ray properties of Narrow-Line Seyfert 1 galaxies

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We present a study of 52 Narrow-Line Seyfert 1 (NLS1) galaxies using archival data from XMM-Newton, Swift, and NuSTAR to investigate their coronal properties. The sample spans a redshift range of $0.002 < z < 0.965$, black hole masses between $6 < \log(M/Msolar) < 9$, and bolometric luminosities from $39.5 < \log(Lbol) < 45.5$. We modeled the X-ray spectra using a combination of a blackbody component, ionized local absorbers, and a reflection model with an embedded cutoff power-law to extract key physical parameters. For a subset ($\sim$47 %) of observations, we obtained well-constrained coronal temperatures and high-energy cut-off values, while for the remaining observations, only lower limits could be determined. The mean coronal temperature and cutoff energy across the sample are found to be around 55 keV and 153 keV, respectively. From spectral fitting, we also derived the average photon index and optical depth to be 2.05 and 2.09, respectively. A statistically significant (Pearson's correlation coefficient 0.38 with p-value < 0.00001) positive correlation between the photon index and the Eddington ratio supports the scenario of high accretion rates in NLS1 galaxies. Moreover, the compactness-temperature diagram shows that all the sources lie away from the pair-production limit, thus indicating that corona in NLS1s are not pair dominated plasma rather normal hybrid plasma.

Long-Term Optical Study of Selected BL Lacertae Sources

Omar Kurtanidze
Abastumani Observatory, Georgia

We present the results of optical monitoring of extragalactic X-ray selected BL Lacertae sources. Ten of them 1ES 0229+200, 1ES 0806+524, 1ES 1011+496, Mrk 180, 1ES 1221+302, 1ES 1426+428, OQ 240, Pg 1553+113, 1ES 1959+650 and 1ES 2344+514 were detected as a very high-energy gamma-ray sources. Our data provide optical information on sources that have previously been rarely observed in the optical band. All observations were conducted in Abastumani Observatory (125-cm and 70-cm meniscus telescopes) and in Calar-Alto Observatory (123-cm and 220-cm telescopes) using different CCD cameras. Variability in R band on long time scales up to 1.25 magnitudes was detected for all of the studied sources.

Formation of black hole seeds within nuclear star clusters at high redshift

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The JWST discovered a population of red galaxies at high redshift. These galaxies are not resolved spatial and are extremely red (Little red dot galaxies, LRDs). There are two possible explanations for the color of the galaxies; (I) LRDs are all AGN, and emission is dominated by the accretion disk, (II) they are all compact star-forming galaxies, and their continuum is dominated by stars. In this talk, I show a set of Monte-Carlo simulations using Galacticus, a semi analytic model for galaxy formation and evolution. We reproduce the observed stellar mass function of LRDs, the bolometric luminosity function, considering different black hole seeding prescriptions within nuclear star clusters, using the MCMC technique, and apply a post processing to delve a physical explanation of such galaxies. We also explore different accretions models, as episodic Eddington accretion, Eddington limited, and Bondy-hoyle.

Scattered synchrotron emission and a giant torus revealed in the polarized light of Centaurus A

Frédéric Marin
Astronomical Observatory of Strasbourg

Centaurus A (Cen A) is the closest radio galaxy and a prime example of a low-luminosity active galactic nucleus (AGN), exhibiting complex emissions across the electromagnetic spectrum. The nature of its continuum emission, particularly the mechanisms powering it, has been a subject of considerable debate due to the fact that the AGN is deeply buried in dust and therefore not directly observable. Using spectropolarimetric data of Cen A obtained with the VLT/FORS2, we explored its total and polarized fluxes, in order to find signatures of the AGN in scattered light. Our analysis demonstrated that a beamed synchrotron jet, scattering onto the narrow line region (NLR) best fits all the observational properties. In this model, the base of the NLR is obscured by an unusually large circumnuclear region and can only become visible through perpendicular scattering onto the outermost part of the NLR, naturally producing high polarization degrees and polarization angles perpendicular to the radio structure. In this presentation, I will show the evidences that Cen A defines a new class of hidden-NLR AGNs in which two other objects naturally find their place (NGC 4258 and 3C 270), also supporting old predictions that beamed synchrotron jets can be observed in reflection.

SIFS view & multi-epoch analysis of NGC5506

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Mega-Hertz Peaked Spectrum (MPS) sources are a type of compact radio galaxies (RGs), with jets confined within <20 kpc. These RGs offer a unique opportunity to study AGN feedback while the jets are still interacting with the dense central region. However, most studies rely on long-slit spectra, leaving open questions about the size, morphology, and origin of the observed outflows. We present the SIFS IFS of an MPS with evidence of ionized gas outflows. We analyze the spatially resolved properties of the ionized gas and compare them with the radio data to assess the AGN's role in the feedback. SIFS observations are key for both temporal mapping and gas diagnostics, serving as a baseline for a multi-epoch, multi-wavelength study to reveal the co-evolution of the jet and the ionized media.

The identification of super-Eddington massive black holes

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We present selection criteria for identifying super-Eddington supermassive black hole candidates based on their location along the Eigenvector 1 (E1) main sequence. Our methodology involves a multi-parametric analysis of large AGN samples, combining optical spectroscopic data with multi-wavelength diagnostics. We define selection thresholds based on quantitative measures of Fe II/Hβ ratios (where as a tracer for Fe II we consider the emission of the optical blend centered at 4570 Å), [O III]$\lambda\lambda$4959,5007 line intensities, CIVλ1549 equivalent widths and shifts, UV diagnostic intensity ratios involving the lines of AlIIIλ1860, SiIII]λ1892, CIII]λ1909, soft- and hard- X-ray photon indexes. We assess how these parameters scale with the inferred Eddington ratio. We deduce that AGN occupying the extreme end of the E1 main sequence, characterized by the most pronounced Fe II emission, are also the most promising candidates for super-Eddington accretion as they converge toward extreme values of the observed multi-frequency parameters and a limiting Eddington ratio of

order unity. Photoionization modeling is then used to validate our empirical criteria over a broad range of cosmic epochs.

Core Shift and Jet Structure in Quasar 3C 279 from Multi-Frequency VLBI Observations

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Jets from active galactic nuclei (AGN) trace relativistic outflows emerging from the vicinity of accreting supermassive black holes (SMBHs), and offer a direct probe of magnetized plasma dynamics under extreme conditions. In this work, we investigate the frequency-dependent position shift of the core in the highly luminous quasar 3C 279 (z = 0.538), using Very Long Baseline Interferometry (VLBI) aiming to constrain the magnetic field strength and opacity profile near the jet base. We analyze eight epochs of quasi-simultaneous VLBI observations at 15, 43, and 86 GHz, reaching an angular resolution of 0.16 milliarcseconds ($\sim$0.9 parsecs). The source structure is modeled through 2D Gaussian components fitted directly to the interferometric visibilities, enabling the identification of the core and innermost downstream jet components at all three frequencies. By aligning optically thin features across frequencies, we determine the frequency-dependent shifts in the apparent core position caused by synchrotron self-absorption. These shifts are used to derive the radial dependence of the magnetic field. We study the jet geometry and estimate the magnetic field strength near its base together with the evolution of parameters of the jet plasma. These estimates will explain if the magnetic field is what makes the jet of 3C 279 so bright.

Chemical abundances of type-2 AGN in different environments

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The chemical abundance of active galaxies with active galactic nuclei (AGN) is often poorly understood due to challenges in isolating AGN effects in metallicity measurements. The chemical abundances of active galaxies in various environments, such as clusters and groups, remain largely unknown. This work employs a novel HCm code (HII-CHI-mistry) to measure chemical abundances in type-2 AGN, analyzing oxygen abundance (12 + log(O/H)), nitrogen abundance (log(N/O)), and ionization parameter (logU) for about 12,000 type-2 AGN from the SDSS survey. We explore the metallicity properties of type-2 AGN relative to host galaxy characteristics like morphology, stellar mass, and star formation rate (SFR), as well as their environments. For galaxies in groups and clusters, we examine metallicity concerning group properties, such as cluster-centric distance and galaxy counts. While we do not observe a strong mass-metallicity relation, we find that in groups and clusters, higher stellar mass correlates with increased 12 + log(O/H) abundance. Additionally, 12 + log(O/H) decreases with rising SFR across all environments. We find no fundamental plane of type-2 AGN, indicating complex interactions among stellar mass, SFR, and metallicity. Type-2 AGN hosts show higher 12 + log(O/H) abundances in groups and clusters than field galaxies, irrespective of redshift. This work contributes the largest catalogue of chemical abundances for type-2 AGN to date.

Incidences and energetics of AGN winds in a distant universe

Blessing Musiimenta
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The feedback phase plays a vital role in galaxy evolution, but identifying AGNs in this phase for robust statistical studies remains a challenge. My presentation will focus on the selection and characterization of AGNs in this phase, emphasizing ionized outflows and their effects on host galaxies. We developed an approach to select powerful AGNs in the feedback phase using optical/IR colours, and optical and X-ray spectral properties from the eROSITA Final Equatorial-Depth Survey (eFEDS). We traced and characterised outflows using SDSS spectroscopy, and explored the link between AGN luminosity and outflow properties. We found that the X-ray selection (eROSITA) is a powerful tool to select AGN in the feedback phase and this X-ray active phase is the best tracer of fast winds. We found a weak correlation between AGN bolometric luminosity and outflow velocity and ∼30% of our sample have kinetic coupling efficiencies within 1-10%. We performed a spatially resolved analysis of a red, X-ray obscured and X-ray luminous quasar, at a redshift of z=0.6. Our analysis reveals that the quasar resides in an interacting system with 3 companion galaxies with AGN-driven outflows that extend up to 9.5 kpc and move at high velocities exceeding 1000 km/s.

AGN driven outflows in an illuminating and interacting red quasar eFEDSJ091157.4+014327 at z ∼0.6

Blessing Musiimenta
INAF - Osservatorio Astronomico di Roma, Italy

The quasar eFEDSJ091157.4+014327 (z 0.6), identified from eROSITA X-ray samples, exhibits red colors, X-ray obscuration ($N_H = 2.7\times10^{22}$ cm^{-2}), and high luminosity ($L_X = 6.5\times10^{44}$ erg s^{-1}), aligning with characteristics of quasars with outflows. It hosts an ionized outflow indicated by a broad [O III]λ5007Å emission line in the SDSS spectrum. This study aims to investigate the quasar's environment, [O III] gas morphology, and outflow kinematics, mass, and energetics using spatially resolved spectroscopic data from the Multi Unit Spectroscopic Explorer (MUSE) with an average seeing of 0.6". The spatially resolved [O III] emission reveals that the quasar is embedded in an interacting and merging system with three other galaxies ∼ 50 kpc from its nucleus. Kinematic analysis shows extended ionized outflows up to 9.2 kpc with positive and negative velocities up to 1000 km s^{-1} and -1200 km s^{-1}, respectively. The kinetic coupling efficiencies, range from 0.01% to 0.03%, with momentum boosts around 0.2, indicating the ionized outflow's low energetic relevance. However, the mass loading factor (∼5) suggests these outflows are AGN-driven rather than star formation-driven. Note that these findings pertain only to the ionized phase, while theoretical models consider multiple phases.

Disentagling the origin of radio emission in radio quiet AGN: A search for corona ”bumps” (cm-submm)

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Supermassive black holes reside in the centers of galaxies, where their activity defines the observable properties of active galactic nuclei (AGN). In radio-quiet AGN, the observed radio emission, typically much fainter than in their radio-loud counterparts, may arise from a complex interplay of mechanisms including weak jets, coronal activity, AGN-driven winds, and surrounding star formation. This project aims to disentangle these contributions by constructing high-resolution, broad spectral energy distributions (SEDs) spanning from cm to sub-mm wavelengths, paired with X-ray observations. By leveraging uniformly resolved interferometric data from arrays such as the VLA, VLBA, and ALMA, we isolate the signature of the coronal emission as a distinct mm “bump” that correlates with X-ray luminosity, thus testing the Neupert effect in AGN contexts. A carefully selected sample of nearby ($z \leq 0.009$) radio-quiet AGN enables rigorous examination of the physical parameters governing nuclear emission processes. The results will improve our understanding of accretion physics, the origin of multi-wavelength emission, and the mechanisms that distinguish the various nuclear components in AGN.

Probing Ionized gas Outflows in the Narrow –Line Region of 4C12.50 with MUSE/VLT

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4C12.50 (IRAS 13452+1232), an Ultraluminous infrared galaxy (ULIRG) and gigahertz the localized effects of active galactic nuclei (AGN) feedback during early evolutionary stages. While compact, massive molecular outflows have been previously observed from this source, the physical properties of ionized gas outflows in the narrow-line region (NLR) remain poorly understood. This study investigates these NLR outflows, where ionized gas interacts with the interstellar medium (ISM) on a scale of ∼100 pc to 1 kpc. Using the Multi-Unit Spectroscopic Explorer (MUSE) with adaptive optics on the Very Large Telescope (VLT), we obtain spatially resolved spectra across the field of view. By analyzing [OIII]/Hβ ratios, we measure the ionized gas mass (M) and velocities (V) to derive the mass outflow rate ($\dot{M}$), energy ($\dot{E}$), and momentum ($\dot{P}$). These measurements enable us to estimate the mass and energy transported to larger radii within the host galaxy and assess whether NLR outflows have sufficient power to significantly impact the host galaxy. Our findings are expected to provide new insights into the role of AGN feedback in ULIRGs.

The broad relationship between X-ray and radio luminosities for AGN

Clara Pennock
The University of Edinburgh

AGN activity is often revealed by strong X-ray and radio emission, even when the AGN is obscured at other wavelengths. Some AGN have been observed to be radio bright but X-ray faint, others X-ray bright but radio faint, as well as bright or faint/unobserved in both X-ray and radio. What determines whether the AGN will be X-ray or radio bright? Is it due to one mechanism that determines both, or two mechanisms in isolation, or even some mixture of the two? We use X-ray and radio data from fields (Bootes, COSMOS) that have been well observed, with large catalogues of multi-wavelength photometry and spectroscopy, to compare sources that are X-ray and/or radio detected. We find that while X-ray and radio luminosities have a tendency to increase with redshift, we do not find any pattern between X-ray and radio luminosity at any given redshift. We also plot radio and X-ray luminosity functions for the radio and X-ray samples as a whole and compare them to the subset that is both X-ray and radio detected. We find that there is a broad range of X-ray luminosity for a given radio luminosity range, and vice versa. This would imply that the instantaneous X-ray power, often a tracer of accretion, is not correlated with the radio power. However, it has also been found that there is an increase in the fraction of radio detected sources for sources with a more luminous X-ray detection, and vice versa. This would indicate a complex link between the X-ray emitting corona and the radio jet.

A Multi-Wavelength Search for AGNs in Low-Mass Galaxies from the MaNGA Survey

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Understanding AGN feedback in low-mass galaxies is crucial for constraining SMBH growth across cosmic time. Since these galaxies likely resemble the primordial building blocks of more massive systems, understanding AGN activity in low-mass hosts offers a unique window into the early phases of SMBH growth. We investigate AGN activity in 27 galaxies with $M_* < 5 \times 10^9, M_\odot$, combining MaNGA data with multi-wavelength AGN selection: mid-IR (WISE), X-ray (Swift/BAT, eROSITA), and radio (NVSS/FIRST). The recent eROSITA data (Sep 2024 release) are particularly effective at revealing obscured AGNs missed by optical diagnostics, expanding our initial sample from 16 to 27 candidates. Optical emission-line diagnostics (BPT, He II) confirm AGN-like ionization in several sources, and we detect broad Hα in 7 galaxies. From line widths, we estimate BH masses of 10^6–$10^7, M_\odot$, supporting the presence of SMBHs in low-mass hosts. Using spatially resolved MaNGA spectroscopy, we map gas kinematics to search for feedback-driven outflows. Our multi-wavelength and kinematic analysis provides compelling evidence that SMBHs can reside in low-mass galaxies and influence their interstellar medium. These results contribute to ongoing efforts to understand black hole–galaxy co-evolution across a wide mass range and cosmic epochs.

The SDSS-V BHM RM Project: Spectral Analysis To Investigate Coordinated Variability in BAL Quasars

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The question of how galaxies form and evolve lies at the heart of extragalactic research. We must understand how galaxies interact with their supermassive black holes (SMBHs) to answer this question fully. Active Galactic Nuclei (AGN) activity may be the result of this interaction. Quasars are commonly quite variable, and continuum and emission line variability provide us with insight into the accretion process of the AGN. Of particular interest are broad absorption lines (BALs) in quasar spectra, which have observed velocity widths greater than 2000 km s^{-1} and are thought to be produced by high-velocity outflows from the quasar accretion disk. By measuring the variability of these BALs, we can constrain the energy contained in quasar outflows and potential significant effects on the host galaxy. We are examining quasars from the Sloan Digital Sky Survey (SDSS) Reverberation Mapping field (SDSS-RM; e.g., Shen et al. 2015) and the SDSS-V Black Hole Mapper survey. SDSS has observed 850 quasars in this field spectroscopically since 2014. Our focus is on a sample of ∼90 BAL quasars observed by both the SDSS-RM and BHM-RM projects. We are finalizing spectral fits using a spectral analysis software known as Prepspec, with which we will examine coordinated variability of BALs, emission lines, and the quasar continuum. We will present preliminary results, including spectral fits for the BHM-RM sample folding in SDSS-V data, and status updates of this investigation.

On the search for rare AGNs with machine learning

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AGNs are among the most energetic phenomena in the universe, detectable across an extensive redshift range extending beyond z>7. Thus, expanding the known AGN population is essential for understanding the accretion physics of SMBHs and galaxy evolution. Variability is a key feature of AGNs, yet the mechanisms behind it are not fully understood, and studying AGNs with anomalous variability can help uncover the processes driving their emission. In this study, we employ machine learning methods on data from the Zwicky Transient Facility (ZTF) to identify AGNs exhibiting unusual variability (e.g. changing-look AGN). We combine high-cadence optical observations from ZTF with 12-band photometry from the Southern Photometric Local Universe Survey (S-PLUS), consisting of 5 broad and 7 narrow bands covering the southern sky, expected to improve detection of sources with subtle spectral features and high-z AGNs. We also introduce QuCatS, a catalog containing over 600,000 quasar candidates with photometric redshifts derived from S-PLUS. Given the significant decrease in known quasars beyond z∼3.5, we also target high-z quasars as potential anomalous candidates. Promising candidates will receive spectroscopic follow-up observations; notably, we have already identified 4 luminous quasars around z 3 using Gemini Telescope data. This work demonstrates the effectiveness of integrating variability analyses and multi-band photometry to deepen our understanding of AGN emission and variability.

Investigating AGN activity in a sample of isolated late-type galaxies

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The growth of supermassive black holes is often linked to galaxy interactions, which drive gas toward the nucleus and fuel AGN activity. However, nuclear emission is also observed in galaxies considered isolated, suggesting alternative triggering mechanisms. These galaxies, free from strong environmental effects, serve as a reference to study ionisation processes in the absence of interactions. We aim to identify the ionising sources in a sample of nearby isolated late-type edge-on galaxies, focusing on whether the ionisation responsible for extraplanar diffuse ionised gas (eDIG), when present, is driven by star formation or nuclear activity. We analyse long-slit optical spectra, obtained along the major axis of 12 galaxies from the Catalogue of Isolated Galaxies (CIG), for which no previous spectroscopic data were available. The sample includes systems both exhibiting and lacking eDIG features identified in Fabry-Perot Hα data. Emission-line ratios are measured and used in BPT and WHAN diagrams to classify the dominant ionisation mechanisms. Most galaxies show line ratios consistent with star formation, but some fall in LINER or Seyfert regions, suggesting the presence of low-luminosity AGNs. Our results show that nuclear activity can arise in isolated environments, and support the use of such galaxies to study AGN triggering in the absence of external interactions.

A striking signature of shocks in compact red quasars?

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Red quasars exhibit a higher incidence of compact (galaxy scale or smaller) radio emission than blue quasars, arising from systems near the radio-loud/quiet threshold. This cannot be fully explained by the standard orientation model, instead favouring red quasars as a distinct phase in quasar evolution - possibly an obscured-to-unobscured transition where low-power jets or AGN-driven winds expel gas and dust. While past studies classified red and blue quasar radio morphologies at a single frequency, radio emission varies across frequencies, with lower frequencies tracing older electron populations. For optically selected red and blue quasars, I compare radio morphologies across 3 surveys (FIRST: 1.4 GHz; VLASS: 3 GHz; LoTSS: 144 MHz) and find red quasars are significantly less likely than blue quasars to show extended low-frequency radio emission, suggesting fewer episodes of past activity and a younger evolutionary stage. Red quasars compact in all three surveys show the highest radio detection rates, with a striking enhancement over blue quasars of detections with steep radio spectral slopes, ($\sim$-1), consistent with AGN-driven wind shocks. Additionally, the fraction of sources with shock-like spectral slopes increases with dust extinction. I suggest these compact red quasars represent a young, “dusty blow-out” phase, where AGN-driven winds and/or compact jets interact with a dusty ISM, causing shocks, leading to steep spectral slopes and enhanced radio detection rates.

Echoes from the Edge: Finding High-Redshift AGN in Radio

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Obtaining a full census of black hole growth in the early Universe is a key piece of the puzzle in early galaxy evolution. Across cosmic time radio-loud AGN are beacons of massive black hole and massive galaxy growth. Currently, there are not many radio-loud AGN known within the first billion years of the Universe, but that number has grown rapidly in the last few years. We now know of several which exist at z>6.5, i.e. in the EoR. With Euclid and other deep+wide surveys we expect to see many more and we could be under-predicting this number. Radio surveys can trace the most massive black holes as well pinpointing AGN too obscured to be found by any other method. Over the last few years we have curated a sample of extreme high-z radio galaxy candidates selected to be bright and compact, but turning over at low radio frequencies as expected at high redshift. These sources are too rare to be found in the narrow JWST deep fields and have to be selected from wide-area surveys. The best candidates have radio to K-band flux ratios $> 10^5$, but have K-band fluxes K>24. I will summarize our results to date including the analysis of the most distant radio galaxy known with L500MHz> 10^{28} W/Hz at z=5.55, evidence of powerful feedback from low accretion rate, billion solar mass black holes. I will also touch on future prospects of selecting rare sources from large area surveys such as Euclid and the SKA pathfinder telescopes.

LX - LUV Relation: Effects of Optical Variability

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Optical variability observed in Active Galactic Nuclei (AGNs) is closely related to the properties and dynamics of their accretion disks and X-ray coronae. Stochastic modelling of optical light curves has shown anti-correlations between variability parameters and fundamental physical properties, such as black hole mass, Eddington ratio, and bolometric luminosity, providing insights into the relative size and geometry of the X-ray corona and accretion disk, as well as the reprocessing of X-ray photons. This information holds significant potential, considering that the precise nature of the interaction between the accretion disk and corona, which governs the observed relationship between X-ray and UV luminosities (LX-LUV), remains an open question. To enhance our understanding of the fundamental processes underlying the LX-LUV relation, we analyse various characteristics of optical variability of blue quasars from the Lusso et al. (2020) sample and investigate the correlations between these variability parameters, fundamental AGN properties, and the dispersion of the LX-LUV relation.

GAMA survey insights into low-z type I quasar host star formation history and close companions

Maria Stone
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In this talk, I will discuss the insights we learned by studying the nearby environments of more than 200 low-redshift Type I quasar fields using archival data from the GAMA spectroscopic survey. We looked at the properties of close companion galaxies to each quasar. Furthermore, we studied the star formation history of the quasar hosts as well. Crucially, our studies have comparison samples of normal (inactive) galaxies. Our results reveal that major mergers are not responsible for the ignition of the AGN in these systems. It is possible that instead minor mergers and secular events (such as bar instability) drive the activation of the central SMBH.

Covariance Spectral Modeling in AGN

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Understanding disc-corona geometry through Xray reverberation studies in Seyfert galaxies is crucial, yet our knowledge mostly relies on flux-averaged mean spectral analysis. In this study, we investigate the origin of the large Xray variability of the Seyfert galaxy NGC 4593 using two XMM-Newton observations, which are at least 65ksec long and have a 0.3 to 10 keV Xray flux difference by a factor of approx 2.5. We extracted mean spectra, Fourier frequency resolved covariance, and time lag spectra, and performed modelling of all spectra in a self-consistent manner. From the best fit covariance spectra for the first time, we have shown that energy-dependent covariance during low flux shows dominance of direct powerlaw continuum over reflection continuum at all fourier frequencies (2.1 to 390 times 10 to the power -5 Hz). However, during high flux, the variabilities are dominated by the reflection components most of the time. Our results are further supported by the Fourier frequency-dependent time lag spectral modelling during high and low fluxes. A significant change is observed in the xray reverberation delay time scale from 483 with uncertainty 135 sec during high flux to less than 96 sec during low flux, indicating a change in coronal size at least by a factor of approx 2 from less than 3.3 Rg to greater than 7.2 Rg during low to high flux transitions.

Probing AGN accretion discs through their variability

Ashley Hai Tung Tan
Australian National University

AGN accretion discs cannot be directly resolved, making flux variability a powerful probe of their internal structure and accretion processes. However, host galaxy contamination complicates variability studies of low-luminosity AGN. To address this gap, we characterise the optical variability of a sample of $\sim$250 low-luminosity AGN at $z < 0.1$ through the ensemble variability structure function using difference photometry. We find that the variability behaviour cannot be described by the Damped Random Walk model often used for quasars and deviates from predictions extrapolated from the well-studied high-luminosity end. This suggests that different physical mechanisms may drive variability in low and high-accretion regimes. We also find differences between the behaviour in the cooler outer disc we probe and the well-studied hotter inner disc, indicating that a more complex accretion disc model may be needed. These findings highlight the need for more comprehensive models that unify AGN variability across the full spectrum of luminosities and Eddington ratios.

SMBHs growth in overdense environments: AGN enhancement in protoclusters with enormous Lyα nebulae

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SMBHs are almost ubiquitous in galaxies' nuclei in the local and in the high-redshift Universe. However, the formation and growth processes that lead to the such massive objects in relatively short timescales are still unclear. A crucial role in accelerating their evolution may be played by the surrounding environment: large quantities of gas and higher merger rates are key to understand how their growth occurs. Protoclusters of galaxies, the precursors of today's galaxy clusters, represent the perfect laboratories to investigate this effect at high redshift. The hunt for the SMBHs population in protoclusters and its characterization requires a multi-wavelength effort to obtain a complete census: in this perspective the X-rays represent the best channel to investigate the AGN activity, even in the most obscured conditions. In this talk, I will present recent deep (>200ks) Chandra observations targeting three protoclusters at z $\sim$ 2-3, that host enormous Lyα nebulae. I will discuss the spectral properties of the detected AGN as well as the effects of overdense environment on the growth of SMBHs. In particular, I will show the fraction of AGN and the X-ray luminosity functions of the protoclusters, which are significantly larger (1 - 2 dex!) than those of their local counterparts. Finally, I will present new results on how the enhancement of SMBHs in overdense environments (x10 larger than SMGs) suggests that protoclusters are indeed optimal sites for promoting their growth.

Homogeneous estimates of black hole masses for JWST AGN at z>4

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The co-evolution between supermassive black holes (SMBH) and their host galaxies, particularly during active galactic nucleus (AGN) phases, is demonstrated by scaling relations. The James Webb Space Telescope (JWST) has observed an abundant population of far SMBHs with a high BH-to-stellar mass ratio, suggesting diverse relations for a high-z AGN compared to the local ones. However, the choice of method used to estimate BH masses can significantly influence the results. To this end, I homogeneously collected public JWST spectra of 65 sources, previously reported in the literature. By fitting these spectra with the Fully Automated pythoN tool for AGN Spectra analYsis, I detected broad Hα components in 50

AGN. I then measured the BH masses using various formulas based on the full width at half maximum and the second order moment of Hα. Comparing the resulting BH masses (both among the different methods and with values reported in the literature) I found that the results are sensitive not only to the chosen method but even more to spectral resolution and data reduction processes. While the scaling relation I obtained is consistent with the literature, showing the high-z sources lying above the local relation, the scatter on the diverse masses values can be even larger than 1 dex. This preliminary study highlights that any evolution in the BH-to-stellar mass ratio over cosmic time may be influenced by the data reduction techniques and the methods applied to estimate BH masses.

The Fraction of Radio-Loud AGN in the Euclid Deep Field North

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Understanding how active galactic nuclei (AGN) evolve with cosmic time and interact with their host galaxies is central to constraining the role of AGN feedback in galaxy evolution. The availability of deep, wide-field surveys now allow for statistical studies of the relationship between radio AGN activity and host galaxy properties across the full AGN population. We examine the radio-loud AGN fraction as a function of redshift and stellar mass by combining LOFAR radio data with Euclid optical/NIR imaging. Earlier studies on radio sources in the local Universe ($z < 0.3$) showed a steep power-law dependence of the radio-loud AGN fraction on stellar mass. Using new data in the Euclid Deep Field North (EDFN), we cross-match 23,309 LOFAR sources with the Euclid Q1data release to obtain optical counterparts and physical parameters, enabling an extension of this relation to $z = 3$ and down to stellar masses of 10^9 $M_\odot$ —a regime previously inaccessible. The combined sensitivity and resolution of Euclid and LOFAR enable the most robust statistical analysis of the radio-loud AGN fraction to date. We find that the powerlaw relation flattens significantly below 10^{10} $M_\odot$, suggesting a shift in AGN accretion mode—from hot, inefficient flows at higher mass to cold gas accretion, likely driven by mergers and interactions in under-dense environments. These results provide new constraints on AGN–galaxy co-evolution models.

What are the configurations of broad-line regions and accretion disks in super-Eddington AGNs?

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Reverberation mapping campaigns of super-Eddington accreting massive black holes (SEAMBHs) have revealed that the broad-line regions (BLRs) are significantly more compact than predicted by the standard R-L relation. In contrast, high accretion rates suggest that the accretion disks are extended. These findings point to the existence of new configurations for BLRs and disks in super-Eddington accreting AGNs. This long-term campaign provides crucial constraints on the physics governing these AGNs.

“So near, and yet, so far” – Spectroscopic redshifts for the G4Jy Sample

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Low-frequency radio emission allows powerful active-galaxies to be selected in a way that is unaffected by dust obscuration and orientation of the radio-jet axis. Currently, there are too few 'radio-loud' galaxies for robust studies in terms of redshift-evolution and/or environment. Hence the use of low-frequency observations over the southern sky to construct a sample that is 10 times larger than the heavily relied-upon 3CRR sample (of the northern hemisphere). This is the GLEAM 4-Jy (G4Jy) Sample, which is a legacy compilation of 1,863 bright radio-sources (White et al., 2020a, 2020b). In this talk I will present the results of widely-awaited multiwavelength analysis, which includes the calculation of intrinsic properties that reveal the true power of these powerful radio-galaxies (White et al., in prep.). This is thanks (in large part) to collating spectroscopic redshifts for 34% of the sample, with 169 of these being new redshifts courtesy of dedicated follow-up on the Southern African Large Telescope (White et al. 2025; Sejake et al., in prep.). I will conclude with remarks on some of the most interesting G4Jy sources, including the famous ”Dancing Ghosts”.

Morphological Classification of Jets in Active Galactic Nuclei

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This work explores the application of machine learning techniques to classifying active galactic nuclei (AGN) with jets based on Very-Long-Baseline Interferometry (VLBI) observations at frequencies 1–90 GHz. Building upon previous work by Fanaroff and Riley, who classified relativistic jets in radio galaxies on kiloparsec scales, we extend this classification to parsec scales, closer to the central supermassive black hole (SMBH). This approach enables detailed study of jet spatial structures and can help enhance accuracy in global positioning systems. We define four morphological classes: single Gaussian source, double Gaussian source, and sources with single or double-sided jets. Synthetic models of AGN jets were generated to create a training dataset for a convolutional neural network (CNN). The CNN was trained on these synthetic data and subsequently applied to classify 130 thousand AGN jet images from the Astrogeo database. The distribution of images into designated classes, predicted by CNN, qualitatively matches the expected outcome. In the near future, this CNN model will become the core of a public online tool for scientists, providing search for morphologically similar images of AGNs.

Unveiling Multicomponent Molecular Feedback in NGC 1068: Insights into AGN-Driven Outflows from ALMA

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Active galactic nuclei (AGNs) impact their host galaxies through powerful winds that drive massive outflows, and these feedbacks can either quench star formation by heating and expelling gas or trigger it by compressing the interstellar medium. The cold molecular phase, which dominates the mass budget of these outflows, is most effectively traced by ^{12}CO emission. In this talk, by utilizing ALMA CO(2-1), CO(3-2), and CO(6-5) data at ∼0.1" (∼7 pc) resolution, I will present temperature, density, and kinematic analyses of the circumnuclear disk (CND) in NGC 1068. We uncover a multi-component molecular outflow varying inside the AGN wind bicone, exhibiting complex, asymmetric motions and a clear misalignment with the ionized outflow. The CO appears optically thin, implying weak coupling to the ionized phase and raising questions about how momentum is transferred across gas phases in AGN feedback. Beyond the observational results, our ongoing work incorporates radiative transfer simulations to investigate the underlying physics of the CO outflow in NGC 1068, with the potential to further reveal its three-dimensional structure and kinematics.