Probing the Genesis of Supermassive Black Holes: Emerging Perspectives from JWST and Expectation toward New Wide-Field Survey Observations

Report of Contributions

https://indico.ipmu.jp/e/440

Contribution ID: **3** Type: **Oral (onsite)**

Opening remarks

Monday 18 November 2024 09:00 (10 minutes)

Presenter: ONOUE, Masafusa (Kavli IPMU)

Contribution ID: **4** Type: **Invited**

Little Red Dots and the Rise of Faint, Obscured AGN at z>5

Tuesday 19 November 2024 09:00 (30 minutes)

One of the more surprising results from JWST has been the discovery of faint, broad-line AGN at z > 5 with luminosities that are 2-3 dex below those of bright quasars found from the ground. I will discuss recent AGN-related results from the CEERS Survey and what they tell us about the growth of SMBHs in the early universe. This includes the discovery of an actively accreting SMBH at z=8.67, which is one of the most distant AGN ever identified. The broad-line AGN identified in our NIRSpec observations are powered by black holes with masses of order 10^7 Msol, making them the least-massive BHs known in the early universe. We derive host stellar masses for each AGN, allowing us to place constraints on the BH-galaxy mass relationship in the lowest mass range yet probed in the early universe. Studies in this low-mass regime are key to constraining models of BH seeding and the early growth history of SMBHs. Finally, I will discuss the discovery of a large population of faint, obscured AGN at z>5 known as little red dots (LRDs). Roughly 80% of these sources exhibit broad emission lines in their spectra and our X-ray spectral analysis confirms that they are moderately obscured, with column densities of log (nH/cm^-2) > 23. The number density of these sources is 2-3 dex above that of bright quasars at z ~ 5-7 and 1 dex higher than current samples of X-ray AGN at z~5. I will discuss the implications of our findings on the fraction of BH growth that is heavily obscured in the early Universe.

Presenter: KOCEVSKI, Dale (Colby College)

Contribution ID: **5** Type: **Invited**

Subaru Telescope as a high-z quasar factory

Monday 18 November 2024 09:10 (30 minutes)

The 8.2m Subaru Telescope features a very stiff structure, enabling us to mount instruments at the prime focus and achieve an unprecedentedly wide field-of-view among the largest optical/near-IR telescopes. Subaru has played a leading role particularly in survey-type observations, e.g., an extensive study of Lyman-alpha emitters in the epoch of reionization. In the past 10 years, we have been carrying out a high-z quasar survey with Hyper Suprime-Cam (HSC) at the prime focus, which can image a 1.5-deg circular field in a single shot. We have so far discovered 200 quasars at $5.6 < z < 7.1$, as well as coeval luminous galaxies and Galactic brown dwarfs. The quasars are typically ~100 times fainter than the luminous quasars reported in previous surveys, and bridge the gap between the latter and extremely faint AGNs recently discovered by JWST. This talk will be a brief review of the project (named SHELLQs; Subaru High-z Exploration of Low-Luminosity Quasars), including results from follow-up observations with JWST and ALMA, and some future prospects.

Presenter: MATSUOKA, Yoshiki (Ehime University)

Contribution ID: **7** Type: **Invited**

Unveiling Early Quasars with Euclid: From candidates selection to follow-up spectroscopy

Monday 18 November 2024 09:40 (30 minutes)

The discovery and study of high-redshift quasars (z > 6) provides crucial insights into the first billion years of the Universe, particularly in relation to cosmic reionization, black hole growth, and galaxy formation. In the era of the JWST and Euclid, our ability to detect and characterize these distant quasars has significantly advanced. In this talk, I will summarize the efforts of the Primeval Universe QSOs Work Package within the Euclid Consortium. Euclid is providing deep photometric observations in the optical (VIS-band) and near-infrared (Y, J, H bands), covering a wavelength range from approximately 0.5 to 2 microns, and will cover a sky area of ∼14,000 square degrees. Additionally, Euclid's slitless grism spectroscopy, covering 0.9–1.85 microns, will enable the identification and characterization of distant quasars through broad emission lines. I will give an update on the status of the Euclid survey and provide an overview of the different selection methods being used to select quasar candidates at the highest redshift. I will also present results from the first spectroscopic follow-up campaigns, including the first confirmed high-redshift Euclid quasars. Finally, I will discuss the challenges encountered in this early phase of the survey and the ongoing efforts to overcome them. The initial campaign for identifying the first quasars with Euclid has yielded promising results, and we expect the survey to uncover hundreds of quasars at z > 7, exciting targets for follow-up characterization with JWST.

Presenter: BELLADITTA, Silvia (Max Planck Institute for Astronomy)

Contribution ID: **8** Type: **Oral (onsite)**

The First High-z Quasar Hunt with Euclid

Monday 18 November 2024 10:40 (20 minutes)

Luminous high-z quasars provide direct probes of the buildup of supermassive black holes, the primeval massive galaxies hosting them, and the intergalactic medium during the epoch of reionization. Despite its extraordinary capabilities, a significant challenge remains: the lack of quasar samples at redshift larger than 7. The Euclid space telescope offers a promising avenue to enrich our quasar samples at redshifts around 7 and to explore the unknown regime at z>7.5. The key to finding these quasar samples among the countless sources in the deep, wide Euclid survey is to select and confirm the candidates much more effectively.

In this talk, I will introduce the first result of Euclid high-z quasar search and the methodology used to select the candidates. Our candidate selection method is grounded in Bayesian probability and density estimation with extreme deconvolution. In the density estimation, we incorporate a new generative model for quasar spectra, which is based on a new compilation of low redshift NIR quasar spectra, and integrate the photometric data from WISE and radio survey to boost the efficiency. The subsequent task involves rapid follow-up confirmations using large, ground-based telescopes, for which we have developed a simulation tool to minimize required exposure times and refine observational strategies. Our first follow-up observation is completed in July 2024. Three new high-z quasars were discovered in just 200 square degrees of the Euclid wide survey. In this talk, I will present the preliminary results and show the lessons we have learnt so far.

Presenter: YANG, Daming (Leiden Observatory)

Contribution ID: **9** Type: **Oral (onsite)**

Proximity zone sizes of z > 6.5 quasars as probes of SMBHs and the IGM in the Epoch of Reionization

Monday 18 November 2024 11:00 (20 minutes)

The study of high-redshift (z>6) quasars is a fundamental key to the understanding of the formation and evolution of the first supermassive black holes (SMBHs) and the history of Reionization. We present the proximity zone size analysis performed on optical and near-infrared spectroscopic observations for a sample of 45 quasars at $6.50 < z \leq 7.64$. This represents the largest medium/moderate-resolution sample of quasars at z>6.5 from ground-based instruments, and its homogeneity and reproducibility make it ideally suited for several scientific goals, i.e., the study of the Ly-alpha forest, the intergalactic medium (IGM) metal content and temperature, as well as other properties such as the quasar luminosity function and the distribution of SMBH masses and Eddington ratios. Starting from this sample, a composite spectrum for evaluating the average rest-frame UV quasar spectral properties has already been produced and analyzed.
Here, we focus on the analysis of the proximity zone size distribution, which is fundamental to inferring information on the quasars' lifetime. Thanks to the reconstruction of the quasar intrinsic blue side from the observed red side (via PCA continuum modeling), we use these quantities to provide more stringent constraints on essential parameters such as the hydrogen neutral fraction at the epoch of Reionization and the radiative efficiency of the first SMBHs. In particular, in this work, we find smaller proximity zones than expected from model predictions. If we rule out the presence of metal absorbers, this evidence could be linked to a 'blinking lightbulb' scenario, in which the quasar periodically turns on and off with a certain duty cycle, and could represent an interesting observational case to study quasar variability on time-scales comparable to the equilibration time.

Presenter: ONORATO, Silvia (Leiden Observatory)

Contribution ID: **10** Type: **Oral (onsite)**

Bolometric Luminosity Estimation from Multi-band Data in SDSS Quasars

Monday 18 November 2024 11:20 (20 minutes)

Bolometric luminosity is a fundamental property that enables us to resolve the central supermassive black hole (SMBH) accretion history. A common method to quantify bolometric luminosity is based on only one monochromatic luminosity. To take advantage of multi-band data, we explore the mid-infrared through ultraviolet spectral energy distributions of ~30,000 SDSS broad-lined quasars with $0.5 < z < 2$. We present a method to calculate bolometric luminosity by matching a few photometric observations in large quasar samples. We show that this method can reduce the systematic error of the bolometric luminosity, and will be useful for calculating the bolometric quasar luminosity function accurately. In addition, we provide the multi-linear regression between bolometric luminosity and monochromatic luminosities for 1450, 3000, and 5100 Angstrom. Our bolometric luminosity measurement can be applied to the quasar population across a wide range of luminosity and redshift.

Presenter: CHEN, Jie (KIAA-PKU)

Contribution ID: **11** Type: **Oral (onsite)**

Understanding black hole accretion flows from nearby stellar binaries to quasars at cosmic dawn

Monday 18 November 2024 11:40 (20 minutes)

AGN spectral energy distributions (SED) are often described by a standard template, but broad-band multiwavelength data clearly show a systematic change, with the bolometric luminosity being increasingly dominated by an EUV component at higher L/LEdd while the X-ray spectra become steeper. I will discuss models of the accretion flow which can follow this behaviour, and draw comparisons to the accretion flow in stellar mass black hole binary systems, where there is a dramatic transition below 0.01LEdd from optically thick, thermal emission to optically thin, hot plasma dominated spectra, most likely due to a transition between a disc and advection dominated accretion flow. Supermassive counterparts of these transitions are seen directly in a few rare examples of 'changing look' AGN, but this is difficult to explore in the wider population due difficulties in constraining a low luminosity nucleus against twin uncertainties from host galaxy and reddening. We use a combination of the eFEDS eROSITA X-ray survey to identify unobscured (and hence unreddened) AGN from their X-ray emission, matched to excellent optical imaging from Subaru's Hyper Suprime-Cam (allowing the subtraction of the host galaxy contamination) to show that this transition is generic. This collapse of the EUV component below 0.01LEdd leads to strong suppression of the broad line region (intrinsic Seyfert 2), with implications for how we identify and select AGN across cosmic time. The changing SED also has implications for the integrated AGN emission in the Cosmic X-ray background and their predicted contribution to reionisation.

Presenter: DONE, Chris (University of Durham / IPMU)

Contribution ID: **12** Type: **Invited**

A personal perspective on primordial black holes

Monday 18 November 2024 13:30 (30 minutes)

The possibility of forming black holes in the early universe was mentioned more than half a century ago. But it had not been seriously studied until recently. Thanks to the rapid progress in gravitational wave astronomy/cosmology, that situation has drastically changed. In this talk, I will review the current understanding and future issues of primordial black holes from my personal perspective.

Presenter: SASAKI, Misao (Kavli IPMU)

Contribution ID: **13** Type: **Oral (onsite)**

Primordial Black Hole Formation from Power Spectrum with Finite-width

Monday 18 November 2024 14:00 (20 minutes)

Primordial Black Holes (PBHs) may be produced by gravitational collapse in regions with a large amplitude of density contrasts in the early Universe. They may provide the seeds for galaxy formation, account for a population of the LIGO-Virgo events, and the candidates of cold dark matter. The main purpose of our study is to develop a more accurate estimation for PBH abundance. We will address the calculation of the PBH abundance by applying peak's theory to primordial field perturbations with a Gaussian probability distribution. Our study may make the application of peak's theory in PBH abundance estimation no longer limited to monochromatic perturbations, power spectrum with any width or shape could be generally solved by handling the smoothing effects in a proper way.

Presenter: WANG, Jianing (Institute of Theoretical Physics, Chinese Academy of Sciences)

Contribution ID: **14** Type: **Oral (onsite)**

Formation of Direct Collapse Black Holes by Super-Competitive Accretion

Monday 18 November 2024 14:20 (20 minutes)

"Stars in the early universe were likely massive. This talk provides an overview of their formation processes and characteristics, then examine the potential for supermassive star formation and the subsequent emergence of direct collapse black holes (DCBHs) in some environments, e.g., characterized by strong far-ultraviolet (FUV) radiation, dense shocks, or dynamic heating from mergers. Challenging the traditional viewpoint, our numerical studies demonstrate that, even in environments with some metallicity (less than approximately 0.1% of solar values)—where dust cooling leads to cloud core fragmentation and the emergence of numerous low-mass stars—accretion flows can still preferentially channel gas to central massive stars, enabling their growth to supermassive objects, similar to the primordial case. This super-competitive accretion process allows only a few stars to become supermassive, along with a large number of low-mass stars. Beyond the 0.1% solar metallicity threshold, metal-line cooling prevents such growth due to smaller accretion rates. Previous analyses have overlooked stellar radiative feedback; however, our recent radiation hydrodynamics simulations have confirmed these findings: the mass spectrum's upper limit remains largely unaffected, while stellar feedback significantly reduces the number of low-mass objects. This new channel of DCBH formation through super-competitive accretion introduces a novel paradigm for the formation of seed black holes, relaxing the constraints imposed by metallicity and increasing the abundance of seed black holes. The talk concludes by assessing whether seed black holes formed in this manner could explain the population of current supermassive black holes."

Presenter: OMUKAI, Kazuyuki (Tohoku U)

Contribution ID: **15** Type: **Oral (onsite)**

Unlocking new pathways to direct collapse supermassive black holes

Monday 18 November 2024 14:40 (20 minutes)

The origin of high-redshift supermassive black holes (SMBHs) has been an intriguing mystery in astronomy and cosmology. Recent observations from James Webb Space Telescope further challenged our previous understanding about their formation mechanism. A promising solution to this problem is the direct collapse black holes from primordial metal-free clouds, which often requires stringent conditions to prevent the fragmentation of the cloud. In this talk, I will show that such conditions for direct collapse can be achieved in several astroparticle physics settings. In particular, the heating from primordial black hole evaporation or radiation from axion like particle decay can effectively prevent the gas cloud from fragmentation and trigger the direct collapse, thus providing SMBH seeds at much earlier time.

Presenter: LU, Yifan (UCLA)

Contribution ID: **16** Type: **Invited**

Entropy in a Coherent Universe: Quantum Information Flows in the Cosmic SuperWeb

Monday 18 November 2024 15:30 (1 hour)

von Neumann of (thermal) quantum entropy fame purportedly responded to Shannon asking what his novel classical information content measure should be called: paraphrasing, entropy, nobody understands it anyway. Nowadays thermal entropy, gravitational entropy and information entropy have merged as ideas, and expanded to encompass phase info as well as counting info, into quantum information aka quantum cosmology. Entropic development and transport through all of the great cosmic epochs of instability accompanying transitions of phase is a unifying story of the Universe. Tis a big topic which I will meander through, from the emergence of coherence, through inflation. its end in the matter-entropy burst, cosmic neutrino background decoupling, cosmic photon decoupling, and entropy development and transport in the gravitationally-unstable nonlinear cosmic web, leading to black holes. With applications to observable entropic relics, such as CnuB, CMB, CIB, etc. One quest is for information-laden Planck-epoch intermittent non-Gaussianities, pinGs, which could generate anomalous collapse on any and all scales, e.g., with possible implications for enhanced early black hole production.

Presenter: BOND, J. Richard (Canadian Institute for Theoretical Astrophysics, University of Toronto)

Contribution ID: **17** Type: **Invited**

UNCOVERing the Nature of ”Little Red Dots”

Tuesday 19 November 2024 09:30 (30 minutes)

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 that 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 (~2-5% of the galaxy population) makes them an important new contribution to the high-redshift galaxy census. 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/or galaxies.

Presenter: GREENE, Jenny (Princeton)

Contribution ID: **18** Type: **Oral (online)**

Physical Pathways for JWST-Observed Supermassive Black Holes in the Early Universe

Tuesday 19 November 2024 10:40 (20 minutes)

Observations with the James Webb Space Telescope (JWST) have revealed active galactic nuclei (AGN) powered by supermassive black holes with estimated masses of 10^7–10^8 M⊠ at redshifts z~7–9. Some reside in overmassive systems with higher AGN to stellar mass ratios than locally. Understanding how massive black holes could form so early in cosmic history and affect their environment to establish the observed relations today are some of the major open questions in astrophysics and cosmology. One model to create these massive objects is through direct collapse black holes (DCBHs) that provide massive seeds (~10^5–10^6 M⊠), able to reach high masses in the limited time available. We use the cosmological simulation code GIZMO to study the formation and growth of DCBH seeds in the early Universe. To grow the DCBHs, we implement a gas swallowing model that is set to match the Eddington accretion rate as long as the nearby gaseous environment, affected by stellar and accretion disk feedback, provides sufficient fuel. We find that to create massive AGN in overmassive systems at high redshifts, massive seeds accreting more efficiently than the fiducial Bondi-Hoyle model are needed. We assess whether the conditions for such enhanced accretion rates are realistic by considering limits on plausible transport mechanisms. We also examine various DCBH growth histories and find that mass growth is more sustained in overdense cosmological environments, where high gas densities are achieved locally. We discuss the exciting prospect to directly probe the assembly history of the first SMBHs with upcoming, ultra-deep JWST surveys.

Presenter: JEON, Junehyoung (University of Texas at Austin)

Contribution ID: **19** Type: **Oral (onsite)**

Challenging the AGN scenario for JWST/NIRSpec broad Hα emitters/Little Red Dots in light of non-detection of NIRCam photometric variability and X-ray

Tuesday 19 November 2024 11:00 (20 minutes)

JWST has uncovered a substantial population of high-z (z>4) galaxies exhibiting broad Hα emission line with a Full Width at Half Maximum exceeding 1,000 km/s. This population includes a subset known as 'Little Red Dots', characterized by their compact morphology and extremely red rest-frame optical colors. If all of these broad Hα emitters were attributed to type 1–1.9 Active Galactic Nuclei (AGNs), it would imply a significantly higher number density of low-luminosity AGNs than extrapolated from that of more luminous AGNs. Here, we have examined the rest-frame ultraviolet (UV)-optical flux variability of five JWST broad Hα emitters using multi-epoch, multi-band JWST/NIRCam imaging data. The rest-frame temporal sampling interval of the NIRCam data (~400–500 days/(1+z)) is comparable to typical variability timescales of AGNs with black hole (BH) masses of M_BH~10^7 M⊠; thus, the flux variations should be detectable if AGNs were present. However, no measurable flux variation over the rest-frame wavelength range of λ_rest ~ 1,500–9,000Å has been detected, placing stringent upper limits on the variability amplitudes. This result, combined with the X-ray faintness confirmed by the ultra-deep Chandra data, indicates that, under the AGN scenario, we need to postulate peculiar Compton-thick broad-line AGNs with either (a) an intrinsically non-variable AGN disk continuum, (b) a host galaxy-dominated continuum, or (c) scattering-dominated AGN emission. Alternatively, (d) they could be non-AGNs where the broad-line emission originates from unusually fast and dense/low-metallicity star-formation-driven outflows or inelastic Raman scattering of stellar UV continua by neutral hydrogen atoms.

Presenter: KOKUBO, Mitsuru (NAOJ)

Contribution ID: **20** Type: **Oral (onsite)**

Little Red Dots: Rapidly Growing Black Holes Reddened by Extended Dusty Flows

Tuesday 19 November 2024 11:20 (20 minutes)

The James Webb Space Telescope (JWST) observations have revolutionized extragalactic research, particularly with the discovery of little red dots (LRD), which have been discovered as a population of dust-reddened broad-line active galactic nuclei. Their unique v-shape spectral feature, which appears blue in the rest-frame UV and red in the optical, as observed through JWST/NIRCam, challenges us to discern the relative contributions of the galaxy and AGN. We study a spectral energy distribution (SED) model for LRDs from rest-frame UV to infrared bands. We hypothesize that the incident radiation from an AGN, characterized by a typical SED, is embedded in an extended dusty medium with an extinction law similar to those seen in dense regions such as Orion Nebula or certain AGN environments. The UV-optical spectrum is described by dust-attenuated AGN emission, featuring a red optical continuum at $\lambda > 4000$ AA and a flat UV spectral shape established through a gray extinction curve at $\lambda < 3000$ AA, due to the absence of small-size grains. There is no need for additional stellar emission or AGN scattered light. In the infrared, the SED is shaped by an extended dust and gas distribution, which allows relatively cool dust temperatures to dominate the radiation, thereby shifting the rest-frame energy peak from near- to mid-infrared bands, which corresponds to the observed-frame wavelength changing from JWST/MIRI to Hershel coverage. This model, unlike the typical AGN hot torus models, can produce an infrared SED flattening that is consistent with LRD observations through JWST MIRI. Such a density structure can arise from the coexistence of inflows and outflows during the early assembly of galactic nuclei. This might be the reason why LRDs emerge preferentially in the high-redshift universe younger than one billion years.

Presenter: LI, Zhengrong (Peking University)

Contribution ID: **21** Type: **Oral (onsite)**

Origin of LRDs and signatures of AGN activity

Tuesday 19 November 2024 11:40 (20 minutes)

The advent of the James Webb Space Telescope (JWST) has revealed a wealth of new galaxies, among which are 'little red dots'(LRDs) at z ~ 4 - 11, a population of previously-hidden, dust-obscured active galactic nuclei (AGNs) powered by 10^6 -10^8 M_⊙ black holes (BHs). In this talk, I will discuss results from 3D cosmological simulation which show that black holes of 10^3-10^5 solar masses can form in atomically cooling halos. They can be the potential origin of the AGNs discovered at high redshifts in the JWST JADES, CEERS and UNCOVER surveys. Furthermore, I will show the estimate of radio fluxes for LRDs and discuss the possibility of theirdetection with radio observatories such as VLA, SKA and ngVLA. The detection of a few hundred nJy radio signal at frequencies > 2 GHz will be a smoking gun for the presence of AGN in LRDs.

Presenter: LATIF, Muhammad (United Arab Emirates University)

Contribution ID: **22** Type: **Invited**

The Age of Discovery with the JWST: Excavating the Signatures of the First Massive Black Holes

Tuesday 19 November 2024 13:30 (30 minutes)

The James Webb Space Telescope (JWST) observations have revolutionized extragalactic research, particularly with the discovery of low-luminosity active galactic nuclei (AGNs) at high redshifts, powered by accreting black holes (BHs) with masses of 10^6-8 Msun. These AGN populations are crucial for understanding early BH assembly and coevolution with their host galaxies. Several remarkable findings distinguish these JWST-identified AGNs from their low-redshift counterparts: (1) their abundance is 1-2 orders of magnitude higher than that of bright quasars, (2) the BH-to-galaxy mass ratio appears significantly higher than the local relationship, and (3) strong absorption features are often seen on top of Balmer emission lines. In this talk, I will review these new results from the first-round of JWST observations, explore theoretical explanations and predictions for those aspects, and propose potentially interesting observations to further investigate the early BH population.

Presenter: INAYOSHI, Kohei (Peking University)

Contribution ID: **23** Type: **Oral (onsite)**

The nature of AGNs newly discovered by JWST at 5<z<6 based on a clustering analysis

Tuesday 19 November 2024 14:00 (20 minutes)

James Webb Space Telescope (JWST) has discovered many faint AGNs at high-z by detecting their broad Balmer lines. However, some of their characteristics are quite different from general type-1 AGN features, such as ~2-3 dex higher number density compared with the extrapolated quasar luminosity function, hosting a very massive SMBH, and no detection in X-rays. Are AGNs newly discovered by JWST (JWST AGNs) really the same population of type-1 quasars? We addressed this issue using a dark matter halo (DMH) mass measured by a clustering analysis. We select 28 JWST AGNs and 679 galaxies at 5<z<6 from the literature and the public galaxy catalogue, respectively. Cross-correlation analysis with angular and projected correlation functions yields the typical DMH mass of JWST AGNs as log (M_halo/h^-1Msun) = 11.53_{-0.27}^{+0.22}, 11.70_{-0.26}^{+0.20}, respectively, which is ~1 dex smaller than that of quasars. The DMHs of JWST AGNs at 5<z<6 are predicted to grow a DMH with 10^12-13 h^-1Msun, a typical mass of quasar at z<~3. Applying the empirical stellar-to-halo mass ratio to the measured DMH mass, their host stellar mass is evaluated as log(M/*Msun)=9.59_{-0.45}^{+0.41} and 9.87_{-0.43}^{+0.32}, which are higher than those estimated from the SED fitting. We also evaluate their duty cycle as f_\duty=0.0065 +/- 0.0006, namely ~*710^6 yr as the lifetime of JWST AGNs. While we cannot exclude the possibility that JWST AGNs are simply low-mass type-1 quasars, these results suggest that JWST AGNs are a different population from type-1 quasars, and may be the ancestors of quasars at z<~3.

Presenter: ARITA, Junya (University of Tokyo)

Contribution ID: **24** Type: **Oral (onsite)**

High-redshift clustering measurements in the era of JWST: modeling the properties of quasars, galaxies, and ”Little Red Dots”

Tuesday 19 November 2024 14:20 (20 minutes)

Clustering measurements have always been foundational in building our understanding of the properties of quasars and galaxies, as well as their (co-)evolution with redshift. Recently, thanks to the advent of the James Webb Space Telescope (JWST), we have pushed the study of clustering well into the era of reionization: several JWST NIRCam/WFSS surveys, such as EIGER and ASPIRE, are measuring the quasar-galaxy cross-correlation and galaxy-galaxy auto-correlation functions at z>6, providing a way to constrain the clustering of luminous quasars and galaxies at these early epochs. However, modeling these measurements is particularly challenging, because of the highly non-linear scales probed by the JWST field of view and the large range of halo masses involved. In this talk, I will present a model that uses these clustering measurements (along with constrain on luminosity functions) to jointly infer the properties of quasars and galaxies in the early Universe. The model builds on a new large-volume dark-matter-only cosmological simulation with more than one trillion particles, FLAMINGO-10k, and returns key quantities such as the mass distribution of quasar/galaxy-hosting halos, the luminosity-halo mass relation for quasars and galaxies and their duty cycle/occupation fraction. I will discuss how these quantities can provide fundamental constraints to the evolution pathways of early SMBHs and galaxies, and examine how measurements at different redshifts reveal the evolution of quasar activity and UV-bright star formation across cosmic time. Finally, I will argue that the clustering of quasars can already give us valuable insight into the properties of the enigmatic “Little Red Dot” population revealed by JWST, and explore how directly probing the clustering of this new population will help us constrain its nature.

Presenter: PIZZATI, Elia (Leiden Observatory)

Contribution ID: **25** Type: **Oral (onsite)**

Quantifying the Coupling Effects of Supernova Feedback on Black Hole Accretion in Galactic Nuclei

Tuesday 19 November 2024 14:40 (20 minutes)

Growth of massive black holes (BHs) in the galactic centers are regulated by the environment. Modern cosmological galaxy-formation simulations suggest that supernova (SN) feedback evacuates the gas in galactic center, suppressing the BH growth until the host galaxies have grown sufficiently to develop a deep gravitational potential, leading to under-massive growth track relative to the local relationship. However, this scenario does not explain the over-massive nature of BHs observed at high redshift through JWST. In this work, we perform a suite of 3D high-resolution hydrodynamical simulations that investigate the properties of turbulent, multi-phase gas driven by individual SN explosions, and the dynamics of accreting gas onto a BH through its gravitational influence radius. We explore a broad parameter space of the BH mass (~ 10^4 - 10^7 Msun), density of the surrounding gas (~ 1-10^5 cm^-3), and frequency of explosions (given by star-formation timescale, tau ~ 10-10^4 Myr). When the density in the nucleus is as high as > 10^3 cm^-3 (tau / 10^2 Myr)^(-2), where the volume filling factor of SN bubbles within the BH influence radius is less than 0.1, the BH is fed at a high rate comparable to the Bondi accretion rate by dense cold gas formed between SN bubbles. This result, unlike most large-scale galaxy simulations that hardly resolve the nucleus, suggests that SN feedback is inefficient to expel the gas and prevent the BH from growing. These high-resolution simulations enable us to provide a physically motivated subgrid feedback model, which can be applied to large-scale simulations.

Presenter: CHEN, Kejian (Peking University)

Contribution ID: **26** Type: **Oral (onsite)**

JADES census of high redshift AGN - probing the origin and growth of the first black holes

Tuesday 19 November 2024 15:30 (20 minutes)

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 balck 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, the first year of results has 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 significant X-ray weakness. In this talk I will present first results from the search for broad line AGN in the JADES survey, showcasing a robust sample of Type 1 AGN spanning redshifts from 2 to 7, commenting on their black hole masses, accretion rates and the properties of their host galaxies. I will also focus on a unique system at z ~ 6.6 in which we discover an over massive AGN residing in a quiescent system, accreting at only ~2% of Eddington luminosity. With a BH mass of 5x10^8 Msun residing in a galaxy with a stellar mass of ~2x10^9 Msun, this is one of the most over massive black holes for its host galaxy in JADES survey and provides compelling evidence of super-Eddington bursts occuring during early black hole growth. In addition, I will talk about potential resolutions to X-ray weakness displayed by many JWST-selected high redshift AGN by presenting a z = 2.3 QSO with Lbol/Lx ratio in excess of 15000 and strong absorption features in the broad Balmer and HeI10830 lines implying NH > 10^24 cm^-2. Such absorption features are also present in some z > 4 AGN of our sample, suggesting Compton-thick medium present in many early AGN.

Presenter: JUODŽBALIS, Ignas (University of Cambridge)

Contribution ID: **27** Type: **Oral (onsite)**

UNCOVERing the first black hole seeds with JWST & Chandra

Tuesday 19 November 2024 15:50 (20 minutes)

JWST is now detecting early black holes (BHs) as they transition from seeds to supermassive BHs. I will present our recent results harnessing the power of the JWST UNCOVER survey combined with Chandra X-ray observations to identify UHZ-1, the first X-ray luminous massive BH at z=10.1. Placing UHZ-1 into context with other z=8-10 luminous active galactic nuclei, we are purportedly now witnessing the growth of the very first BHs. This large population of massive, and often heavily obscured BHs were rapidly growing at only t~<0.5 Gyrs, and were residing in galaxies with masses similar to that of the BH – two to three orders of magnitude higher than local BH-to-stellar mass ratios and consistent with a picture wherein such BHs originated from heavy seeds.

Presenter: GOULDING, Andy (Princeton)

Contribution ID: **28** Type: **Oral (onsite)**

Broad-Line AGN at 3.5 < z < 6: The Black Hole Mass Function and a Connection with Little Red Dots

Tuesday 19 November 2024 16:10 (20 minutes)

Observational constraints on the evolution of active galactic nuclei (AGN) are key for constraining the origins and evolution of supermassive black holes (BHs) across cosmic time. In this talk, I present a sample of 50 H-alpha detected broad-line AGN (BLAGN) at redshifts 3.5<z<6.8 using data from the CEERS and RUBIES JWST/NIRSpec Surveys. I compute rest-frame ultraviolet and optical spectral slopes for these objects, and determine that 10 BLAGN in our sample are also little red dots (LRDs). I discuss the overlap and connections between the LRDs and BLAGN. I next construct the BH mass function at 3.5<z<6. This BH mass function shows broad agreement with both recent JWST observations as well as theoretical models, indicating that the observed abundance of BHs in the early universe is not discrepant with physically-motivated predictions. This BH mass function is largely featureless, and resembles a power-law. This may indicate that any signature from black-hole seeding has been lost by redshift z~6. I compute the BLAGN UV luminosity function and find good agreement with JWST-detected BLAGN samples from recent works, finding that BLAGN hosts constitute <10% of the total observed UV luminosity at all but the brightest luminosities. Finally, I discuss future plans to better expand and refine the BH mass function at redshift 3-9 using current, planned, and proposed data from JWST.

Presenter: TAYLOR, Anthony (The Univeristy of Texas at Austin)

Contribution ID: **29** Type: **Oral (onsite)**

A Search for z=5 Halpha and Hbeta+[O III] Dual-Line Emitters in JWST/CEERS Field

Tuesday 19 November 2024 16:30 (20 minutes)

The unprecedented sensitivity and resolution of the James Webb Space Telescope (JWST) have enabled us to uncover faint galaxies and AGNs in the early universe. Using their special colors shown in the JWST/NIRCam bands and compactness measurements, we report the discovery of 261 Hbeta+[O III] and Halpha dual-line emitters, including 58 AGN candidates (22%) which have compact morphology at rest-optical wavelength in the field of the CEERS project.
These objects have Hbeta+[O III] emission in F277W and Halpha in F410M, thus, their redshifts are restricted to 5.03<z<5.26.
This method is peculiar, so that our AGN candidates are unique, except for one confirmed AGN with the same color behavior.
These dual-line emitters have an absolute UV magnitude range MUV~-17 to -22 and their rest-UV luminosity function indicates that this population comprises ~40% of the total star-forming galaxy population at this redshift. The number density of AGN candidates is significantly higher than the extrapolation from the luminous counterparts but is comparable to other measurements from JWST.
With an assumption of 26% Eddington ratio, our AGN candidates are expected to have black hole masses of 10^{6}–10^{7} Msun.

Presenter: GUO, Jingsong (Peking University)

Contribution ID: **30** Type: **Poster**

Poster Flash Talk1: CSTACK: Stacking Analysis of Chandra Images On the Web and X-rays from :"Little Red Dots"

Tuesday 19 November 2024 16:50 (10 minutes)

"The CSTACK Tool (http://lambic.astrosen.unam.mx/cstack/) is a public tool for X-ray stacking analysis on several deep fields observed with Chandra for probing the average X-ray flux of populations of sources. As JWST data in deep fields are becoming available, we notice a recent increase in CSTACK. use. In this poster, we introduce the tool and explain its functions and usages,
As an example of its use, we report the recent detection of stacked X-ray emission from a population of faint high-redshift objects ""Little Red Dots"" (LRDs) found by JWST (Yue et al. ApJL accepted„ arXiv:2404.13290)."

Presenter: MIYAJI, Takamitsu (Instituto de Astronomia Ensenada, UNAM)

Contribution ID: **31** Type: **Poster**

Poster Flash Talk2: Obscured AGNs in the third Deepest XMM-Newton Field

Tuesday 19 November 2024 16:50 (10 minutes)

"In this project, we present preliminary results from a systematic X-ray analysis combined with multiwavelength photometric and spectroscopic data to identify and characterize obscured and highly obscured (Compton-Thick or CT) AGNs in the XMM-Newton 1.75 Ms Ultra Narrow Deep Field (XMM175UNDF) survey, one of the deepest XMM-Newton survey to date.

We analyzed a sample of 118 X-ray AGNs with redshifts up to z ~ 2.5 and optical/Infrared counterparts. We searched for typical multi-wavelength signatures of CT-AGNs, based on their spectral energy distribution (SED), UV/optical-mid-IR photometric colors, and X-ray spectroscopic features such as FeKα emission line intensity and reflected component.

We explored potential correlations between the main spectral properties of the obscured AGN population, such as column density, luminosity, FeKα line, photon index, and black hole mass. We found evidence of an anti-correlation between the luminosity and the FeKα line equivalent width (known as the "Iwasawa-Tanigushi effect"), suggesting this relation prevails in the most obscured AGNs. Additionally, we observed an over density distribution of obscured AGNs around a cosmic filament at z = 0.44, potentially linked of dust lanes in the host galaxy or underlying presence of BAL QSOs at this redshift."

Presenter: ELÍAS CHÁVEZ, Mauricio (Universidad Nacional Autónoma de México)

Contribution ID: **32** Type: **not specified**

discussion

Tuesday 19 November 2024 17:00 (30 minutes)

Contribution ID: **33** Type: **Invited**

Search for high-z AGN in the era of JWST in the JADES survey

Wednesday 20 November 2024 09:00 (30 minutes)

Detection of supermassive black hole seeds and the first AGNs in the Universe are some of the key questions at the frontier of galaxy evolution. With the launch of JWST, we are now able to observe the rest-frame optical and UV lines at z>8. These tracers are necessary to detect emission coming from these first AGNs in the Universe, constraining the theoretical models on the origin of supermassive black holes and role of AGN in galaxy evolution in general and re-ionisation in particular. The latest results, showed that black holes and galaxies have evolved much faster than initially thought, In the talk, I will present the results from our effort in the JADES and GA-NIFS surveys to describe the build up of black holes and their influence of their host galaxies using both deep spectroscopy and imaging. I will present our effort to identify both type-1 and type-2 AGN, their selection process, properties as well as their origin by pushing the detection of BH pass z=11.

Presenter: SCHOLTZ, Jan (Cambridge)

Contribution ID: **34** Type: **Oral (onsite)**

Placing a Compact, Red AGN at z=7.27 in Perspective - A First Measurement of AGN-Galaxy Clustering at Cosmic Dawn

Wednesday 20 November 2024 09:30 (20 minutes)

"Deep spectroscopic JWST observations have recently unveiled an emerging population of faint z>5 active galactic nuclei (AGN) with supermassive black hole (SMBH) masses of 10^6-10^8 solar masses. Their often compact, red appearance in JWST/NIRCam imaging earned them the nick name "little red dots"and is likely due to large amounts of intrinsic dust-reddening. First estimates of their number densities exceed the expectations from extrapolating the quasar luminosity function by factors of 100, possibly constituting as much as 10% of the total galaxy population. While the detection of these "infant"growing SMBHs has begun to reshape our view of the early universe and SMBH evolution, how exactly they fit into the larger picture of cosmic structure formation is unclear.

I will present the discovery of a new faint AGN at z=7.27, classified by broad-line components (FWHM > 2000 km/s) to the Hb and Hg emission lines in our NIRSPec/PRISM spectroscopy. The spectral shape is significantly affected by dust-reddening, producing JWST colors typical for these "little red dots". We estimate a SMBH mass of ~10^8 solar masses with an Eddington ratio between 15%-30%, depending on the assumed reddening correction.

Our NIRSpec MSA observations have further revealed 8 associated galaxies to the AGN within a 2500 km/s window in the Hubble flow. Based on this sample, I will present an AGN-galaxy clustering measurement at z>7, placing this new AGN population in context with structure formation for the first time."

Presenter: SCHINDLER, Jan-Torge (University of Hamburg)

Contribution ID: **35** Type: **Oral (onsite)**

A comprehensive search for dusty AGNs using a pixel-by-pixel color selection method from JWST imaging data

Wednesday 20 November 2024 09:50 (20 minutes)

Deep IR observations by JWST have discovered a large number of high-z, red, and compact objects called "little red dots"(LRDs). Based on the detection and analysis of broad emission lines, previous studies have argued that LRDs are low-luminosity AGNs hosting overmassive black holes. However, previous LRDs selection is mainly based on color and compactness criteria, potentially biasing results towards AGN-dominant cases where the host galaxies are undetected. To address this, we apply a pixel-by-pixel color selection method to JWST/NIRCam imaging data, aiming to identify LRDs/dusty-AGNs with extended or nearby components that may represent their host galaxies or merger counterparts. We confirm that our selection method finds previously identified LRD candidates with high completeness. Moreover, our method selects LRDs missed by typical selection methods: LRDs with extended components or nearby components, including the first dual LRDs. In this presentation, I will introduce our novel selection method and, based on the analysis of the selected objects, discuss the evolution of LRDs and high-z SMBHs.

Presenter: TANAKA, Takumi (the University of Tokyo / Kavli IPMU)

Contribution ID: **36** Type: **Invited**

The Obscured Growth of Early Supermassive Black Holes: Insights from X-rays and Beyond

Wednesday 20 November 2024 10:40 (30 minutes)

"Deep X-ray surveys have long been the most effective method for uncovering obscured Active Galactic Nuclei (AGN) in the distant Universe, revealing that the growth of supermassive black holes (SMBHs) becomes increasingly shrouded in obscuration at earlier cosmic times. However, even the most extensive X-ray surveys to date struggle to uncover and thoroughly understand the physics and demographics of heavily obscured SMBHs during the Universe's first billion years.

In this talk, I will explore potential physical explanations for the rising levels of nuclear obscuration with redshift, discuss the future potential of next-generation X-ray facilities to probe early SMBH activity, and examine the challenges posed by the unexpected lack of X-ray emission from the large population of high-redshift AGN recently identified by JWST. I will also highlight possible alternative approaches to studying these early black holes."

Presenter: GILLI, Roberto (INAF-OAS Bologna)

Contribution ID: **37** Type: **Oral (onsite)**

AGN under the Eye of JWST: Insights into their high-z properties

Wednesday 20 November 2024 11:10 (20 minutes)

"In this talk, I will present key results on the selection of high-redshift AGN and their peculiar properties. Specifically, I will introduce three new narrow-line AGN diagnostic diagrams, leveraging the [OIII]4363 auroral line, which has been detected in several JWST spectra. These diagnostics effectively differentiate much of the AGN population from Star-Forming Galaxies (SFGs) and have proven capable of selecting AGN at z>6, where traditional narrow-line AGN (NLAGN) diagnostic diagrams fail due to the different conditions of AGN host galaxies.
For the first time, I applied these new AGN diagnostics in the spectroscopic selection of NLAGN among the ~ 300 publicly available medium-resolution spectra of the CEERS survey, identifying 52 NLAGN up to z~9. I conducted a detailed multiwavelength analysis of these sources, and I will present the main findings. Notably, given the availability of deep X-ray observations for this field, I investigated the X-ray properties of the selected NLAGN. I found that all but four NLAGN are undetected in the deep X-ray image, as well as all the high-redshift BLAGN previously selected in the literature from the same survey. Even stacking the undetected sources did not result in a detection, revealing an X-ray weakness of 1-2 dex compared to what is expected based on their bolometric luminosities.
Lastly, I will present results related to the radio analysis of ~20 broad-line AGN selected with JWST. Investigating the radio emission of these sources is crucial for distinguishing between the heavily obscured AGN scenario and intrinsic X-ray weakness as the cause of the observed X-ray deficiency in these sources."

Presenter: MAZZOLARI, Giovanni

Contribution ID: **38** Type: **Oral (onsite)**

SHELLQs narrow-line quasars observed with Chandra and JWST

Wednesday 20 November 2024 11:30 (20 minutes)

Twenty or more narrow-line (FWHM<500 km/s) quasars have been discovered through the high-z quasar search project SHELLQs, based on the Subaru HSC Survey. Their narrow but luminous Ly_alpha make them good candidates of obscured quasars at z > 6, that are expected to be abundant. Besides the discovery spectra in the rest-frame UV band, JWST-NIRSpec data of 9 objects have been acquired during the Cycle-2. Many of these spectra exhibit broad Balmer emission at the base of narrow lines, similar to the fainter JWST-selected AGN. We selected four objects as promising obscured quasar candidates that are characterised by exceptionally faint UV continuum and large Ly_alpha luminosity exceeding 10^44 erg/s to observed with Chandra. However, these X-ray observations resulted in no detection in the rest-frame 7-35 keV band, placing them in the X-ray faint regime. If heavy obscuration plays a role, it should occur at inner regions, given small Balmer decrements seen in narrow lines of the JWST spectra. Along with other possible explanations, we consider supercritical accretion for the high-z quasar population and, due to the inherent anisotropy of radiation in the supercritical accretion flow at innermost radii, the X-ray faintness of our SHELLQs narrow-line quasars might arise from an orientation effect.

Presenter: IWASAWA, Kazushi (ICREA & Universitat de Barcelona)

Contribution ID: **39** Type: **Oral (onsite)**

Uncovering the Type-2 QSO Population at High Redshift Using Keck, Gemini and Euclid

Wednesday 20 November 2024 11:50 (20 minutes)

Tracing the buildup of supermassive black hole (SMBH) mass across cosmic time requires a full census of the active SMBH population, including obscured type-2 quasars. Active galactic nuclei unification predicts similar number counts of type-1 and type-2 quasars. The JWST discovery of LRDs indicates the obscured fraction may be much higher than we expected. However, to date only dozens of type-2 quasars have been spectroscopically confirmed at z>2, constituting a major unsolved problem for SMBH demographics. We select high-redshift Type-2 candidates using the optical survey (SDSS, Legacy Survey) and mid-infrared survey (WISE) data. We have selected more than 300 new Type-2 candidates using our selection and conducted the spectroscopic confirmation. We have got GEMINI/GNIRS spectra for 24 candidates and Keck/LRIS spectra for 43 candidates. 31 new z > 2 Type-2 AGNs are successfully identified and they are the most IR-luminous Type-2 AGNs at high-z. Many quasars are confirmed through their Lya-nebula and sometimes the Lya-nebula is the only convincing feature we see from the 2-D spectra.Some targets show very similar spectra to LRDs and the stacked SEDs have similar rest-UV light which can be explained by the scatter light, like LRDs. We also fit the hot dust torus template to LRDs and find that the LRDs can have hot dust. The LRDs with hot dust could be high-z Type-2 QSOs and we are using Euclid to find more Type-2 QSOs at z>4. The composite photometry mde by this project will also guide us on how to find high-z Type-2 ANG and better understand the obscured fraction , true nature of LRDs at high-z using Euclid and JWST.

Presenter: WANG, Ben (Leiden Observatory/Tsinghua University)

Contribution ID: **40** Type: **Oral (onsite)**

Unveiling heavily obscured SMBH growth at z>3

Wednesday 20 November 2024 12:10 (20 minutes)

Heavily obscured AGN in the early universe are an important population that represent an early, violent growth phase of SMBHs and their host spheroidal components. We performed a MIPS 24um search for z>3 heavily obscured AGN in the XMM-LSS and COSMOS fields, focusing on their strong rest-frame NIR emission originating from AGN hot dust. As a result of the selection, approximately 90% of the selected sources were not detected by the deep X-ray surveys in these fields. SED fitting analysis of all selected candidates revealed that the AGN bolometric luminosities reach log(L_bol)~46–48, indicating that they are heavily obscured and host SMBHs in a vigorous growth phase. The estimated cosmic SMBH growth rate, including heavily obscured AGN, significantly exceeds previous X-ray study estimates. In addition, current available archival JWST high-resolution images (COSMOS-Web, PRIMER) showed the diverse morphology of their hosts, particularly favoring clumpy structures. These results emphasize the critical role of obscuration in early SMBH growth and how next-generation wide-field surveys and multi-wavelength facilities can uncover these hidden populations, enhancing our understanding of the cosmic accretion history in the early universe.

Presenter: MATSUMOTO, Naoki (Tohoku U)

Contribution ID: **41** Type: **Invited**

Probing the cold interstellar medium and star formation in the quasar host galaxies at the earliest epoch

Thursday 21 November 2024 09:00 (30 minutes)

Quasars discovered at the highest redshift provide a unique opportunity to study the early growth of the first supermassive black holes (SMBHs) and their host galaxies at the reionization epoch. Extensive observations were conducted out using large submillimeter/millimeter/radio telescopes and interferometer arrays to investigate the dust continuum, molecular CO, and fine structure line emission from the young quasar host galaxies at z>~6. The results reveal active star formation in the central few kpc region of the quasar host galaxies with highly excited molecular gas. In this talk, I would like to review the observational constraints on star formation, gas excitation, and gas kinematics in these young quasar host galaxies, and discuss our understanding of the co-evolution of these SMBH-galaxy systems at the earliest epoch.

Presenter: WANG, Ran (Peking University)

Contribution ID: **42** Type: **Oral (onsite)**

Probing quasar host galaxies with spectrophotometric decomposition

Thursday 21 November 2024 09:30 (20 minutes)

The co-evolution of AGN/SMBHs and their host galaxies is one of the main topics in the field of galaxy evolution. The key is to understand the relation between the masses of SMBHs and the properties of their hosts. For quasars where AGN are in the most active phase, their brightness prevents us from directly probing their host galaxies in the optical. Previous studies usually rely on two independent methods to estimate the host galaxy components, including imaging decomposition and spectral decomposition. Results from two different methods were often inconsistent, and information drawn from individual methods was limited. To better understand quasar host galaxies and their relation with SMBHs, we propose to apply our recently developed spectral fitting code to the Subaru Hyper Suprime-Cam (HSC) imaging data and DESI spectral data. Our code performs both imaging and spectral decomposition and takes advantage of both methods that allow a robust decomposition of the AGN and galaxy components. In our method, we first do imaging/morphological decomposition in five HSC broad bands and set constraints on the flux ratios of host galaxy to AGN in different bands. With these flux ratios, we perform a global spectral fitting of the DESI quasar spectrum and derive host galaxy parameters. This method can help us break the degeneracy of the quasar and host galaxy components in the spectral fitting and better determine the host galaxy properties of DESI quasars. We mainly use Bagpipes for the spectro-photometric joint modeling of the host galaxy component in our fitting. Our current sample of quasars selected from the DESI DR1 (Iron) is confined to those showing extended morphologies in the HSC images, whose sample size is around 2000. We will extend this spectral decomposition work to future DESI quasar spectra, especially the discovered Changing-look AGNs in DESI quasars. This study illustrates the importance of host galaxy spectral components in quasar spectra and will expand the current knowledge of quasar host galaxies with the wealth of DESI quasar spectra.

Presenter: SUN, Shengxiu (Peking University)

Contribution ID: **43** Type: **Oral (online)**

The Extreme Local Environments of High-z Quasars

Thursday 21 November 2024 09:50 (20 minutes)

The environments of high-redshift quasars are a key probe of the formation and growth of supermassive black holes in the early Universe. With JWST, we can study their local kpc-scale environments in great detail. Here I will present our latest work using the NIRSpec IFU to study high-z quasars and their host galaxies. In the GA-NIFS program, we have discovered a large number of interacting companion galaxies around our sample of quasars, undergoing significant mergers with the quasar hosts. We have also discovered a quasar undergoing a trainwreck merger with multiple galaxies and a tidal stream as part of the PEARLS program. 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.

Presenter: MARSHALL, Madeline (Los Alamos National Laboratory)

Contribution ID: **44** Type: **Oral (online)**

Unveiling the Cosmic Cradles: Morphological Analysis of a Sample of z~6 Quasar Host Galaxies

Thursday 21 November 2024 10:40 (20 minutes)

The James Webb Space Telescope (JWST) has revolutionized our understanding of the early universe, particularly in the study of quasars (QSOs) at redshifts beyond 6. In this talk, I will present groundbreaking results from our Cycle 1 JWST program, which targeted 12 QSOs from the Hyper Suprime-Cam Subaru Strategic Program (HSC-SSP). Our analysis has successfully detected host galaxies for the majority of these targets. I will discuss the size-mass relationship of these distant quasar host galaxies and its intriguing alignment with the star-forming galaxy relation from the COSMOS-Webb sample. Additionally, I will present a comparative analysis of the host galaxy morphologies we've detected, offering unprecedented insights into the nature of these early cosmic structures.

Presenter: DING, Xuheng (Wuhan University)

Contribution ID: **45** Type: **Oral (onsite)**

Tip of the iceberg: overmassive black holes at 4<z<7 found by JWST are not inconsistent with the local MBH-M* relation

Thursday 21 November 2024 11:00 (20 minutes)

JWST is revealing a remarkable new population of high-redshift (z>4), low-luminosity Active Galactic Nuclei (AGNs) in deep surveys and detecting the host galaxy's stellar light in the most luminous and massive quasars at z~6 for the first time. Recent findings claim that SMBHs in these systems are significantly more massive than predicted by the local MBH-M*relation and that this is not due to sample selection effects. Through detailed statistical modeling, we demonstrate that the coupled effects of selection biases (i.e., finite detection limit and requirements for detecting broad lines) and measurement uncertainties can largely explain the reported offset and flattening in the observed mass relation towards the upper envelope of the local relation. We further investigate the possible evolution of the MBH-M* relation at z>4. The bias-corrected intrinsic MBH-M* relation in the low-mass regime suggests a large population of low-mass BHs (MBH<10^5), possibly originating from lighter seeds, may remain undetected or unidentified. These results underscore the importance of forward modeling observational biases to understand BH seeding and SMBH-galaxy coevolution mechanisms in the early universe, even with the deepest JWST surveys.

Presenter: LI, Junyao (UIUC)

Contribution ID: **46** Type: **Oral (onsite)**

Extended emission in the NIRSpec Fixed Slit spectra of twelve z~6 SHELLQs quasars

Thursday 21 November 2024 11:20 (20 minutes)

We present JWST/NIRSpec fixed slit spectra of 12 z~6 low-luminosity quasars and their host galaxies from the HSC SHELLQs sample. By modelling and subtracting the point-source quasar profiles from the 2D spectra, we reveal emission from the quasar's host galaxy extending at least 3 kpc. Of the 12 extracted spectra, at least seven show extended emission from the [OIII] 4959/5007 doublet and/or Balmer lines, and at least two sources show evidence of an extended stellar continuum. We present analysis of these extended spectra, inferring host galaxy properties and comparing to hosts of low-luminosity quasars at lower redshifts.

Presenter: PHILLIPS, Camryn (Princeton)

Contribution ID: **47** Type: **Oral (onsite)**

The evolutionary trend of high-z SMBHs in co-evolution with host galaxies regulated by super-Eddington accretion and outflows

Thursday 21 November 2024 11:40 (20 minutes)

The unprecedented sensitivity of the JWST has led to the discovery of numerous supermassive black holes (SMBHs) with high black hole (BH)-to-galaxy mass ratios. This elevated mass ratio is thought to arise from the massive nature of seed BHs, which are believed to dominate the host galaxy's mass at the time of their formation. However, as seed BHs undergo different growth trajectories, the evolution of this mass ratio can diverge, making it challenging to maintain the initial ratios. In this talk, we apply a BH growth model to the merger history of dark matter halos to explore the emergence and evolution of high BH-to-galaxy mass ratios, taking into account galactic gas feeding and BH accretion feedback.

In our model, we attribute the specifics of feeding and feedback to the power-law index in the inflow rate profile M_inflow\propto r^p, which defines how gas is fed to the BH in the presence of powerful outflows. Our findings show that overmassive seed BHs tend to grow slowly (albeit at accelerated rates) toward the local relation, while undermassive seed BHs grow rapidly (yet at decelerating rates) to converge with the local relation.

Additionally, we introduce a stellar mass-dependent model for outflow strength that reflects realistic feedback mechanisms. In this framework, the early growth of seed BHs is initially suppressed but becomes more active once host galaxies reach sufficient mass to counteract the feedback. These rapidly growing BHs can naturally evolve into the observed SMBHs, maintaining a high BH-to-galaxy mass ratio of approximately 0.1.

Our model also provides an analytical derivation of the BH-to-galaxy mass ratio at epochs following their seeding, as a function of the feedback strength parameter, p. We demonstrate that the final mass ratio depends on the threshold between positive and negative second-order derivatives. The observed high mass ratio SMBHs at high redshift suggest that moderate (or even weak) feedback played a role in the early universe when seed BHs were growing rapidly.

Presenter: HU, Haojie (Center for Computational science, University of Tsukuba)

Contribution ID: **48** Type: **Oral (onsite)**

The Connection between Galaxy Star Formation Rates and Supermassive Black Hole Accretion Rates from z=0-10

Thursday 21 November 2024 13:20 (20 minutes)

We discuss the relationship between black hole and galaxy growth, as inferred from observations using the TRINITY empirical model. Key findings include: 1) the ratio between cosmic SMBH accretion rate and galaxy star formation rate stays constant at ~0.002 from z=0–4, and decreases at z>4; 2) the average SMBH Eddington ratio increases towards higher redshifts, nearly reaching η=1 at z~10; 3) at fixed redshift for z<3, SMBHs/galaxies with higher masses have lower Eddington ratios, consistent with AGN downsizing; 4) the average ratio of specific SMBH accretion rate (SBHAR) to average specific star formation rate (SSFR) is nearly mass-independent, with a value SBHAR/SSFR~1, which decreases slightly from z=10 to z=0; 5) similar to galaxies, SMBHs reach their peak efficiency to convert baryons into mass when host halos reach 10^12 M⊠. These findings combine to give a simple explanation for massive (10^9–10^10 M⊠) quasars at z>6: at these redshifts, dark matter halos experience ~Eddington specific growth rates, driving ~Eddington specific growth rates in both galaxies and SMBHs.

Presenter: BEHROOZI, Peter (University of Arizona / NAOJ)

Contribution ID: **49** Type: **Oral (onsite)**

A NIRSpec/IFU view of a quasar-galaxy merger at cosmic dawn

Thursday 21 November 2024 13:40 (20 minutes)

Quasars are among the most active sources emerging in the early universe (z > 6). Their host galaxies have stellar masses and star formation rates orders of magnitude higher than what is observed in typical galaxies at the same redshifts. Investigating these sources is thus necessary if we want to unveil how the first massive galaxies formed. Here we present the rest-frame optical spectrum of a z = 6.23 quasar obtained with JWST/NIRSpec IFU. The spectrum shows the quasar emission with exquisite quality (S/N ~ 100 - 400 per spectral element). As shown by previous ALMA and HST data, the quasar presents two companion galaxies and lies within a prominent Lyman-alpha halo. This makes this source a perfect target to investigate several aspects, such as, the black hole properties, the quasar-host and companion galaxies, and the environment. Specifically, the NIRSpec data provide us with: Accurate estimates of the black hole mass and the Eddington ratio; study of AGN feedback via ionized outflows. A map of the ionized gas in the host galaxy and companion sources, showing a complex velocity structure, which enables a detailed study of the dynamics within this system; A chart of the photoionization conditions in the gas, which enables shedding light on the physics of the interstellar medium (metallicity, hardness of the ionization field, powering source, etc); A map of the halo seen in Halpha, which reveals resonance scattering as the main mechanism powering the Lyman-alpha halo. These data offer a deep insight into the assembly and early growth of the first massive galaxies and black holes.

Presenter: LOIACONO, Federica (INAF OAS Bologna)

Contribution ID: **50** Type: **Oral (onsite)**

Dimming blinding floodlights with JWST/NIRSpec IFU: Spatially resolved gas kinematics in the most distant luminous quasar at z=7.6

Thursday 21 November 2024 14:00 (20 minutes)

With the advent of the James Webb Space Telescope (JWST), the study of supermassive black hole (SMBH) and host galaxy co-evolution has entered an unprecedented era, pushing the quasar redshift frontier to z~7.6. In this talk, I will present the first detailed kinematic analysis of the extended rest-frame optical emission in J0313-1806, the most distant luminous quasar currently known, using data from JWST/NIRSpec Integral Field Unit (IFU). Previous observations revealed that J0313-1806 harbors a 1.6-billion solar-mass SMBH within a massive, dusty, and intensely star-forming galaxy (Wang et al. 2021). Its rest-frame UV spectrum shows broad absorption lines and significantly blueshifted CIV broad emission, pointing to the presence of powerful quasar-driven outflows.

JWST/NIRSpec IFU data provide a remarkable view into the detailed kinematics of this quasar-host system, allowing us to map the spatial distribution of nuclear emission, extended gas, and underlying stellar components. We employ advanced cube-analysis techniques to overcome the extreme contrast between the bright quasar core and its surrounding nebula. The resulting flux, velocity, and velocity dispersion maps across the 3”x 3”region around the quasar reveal complex gas dynamics, including the presence of a large, outflowing shell-like structure extending several kpc from the central SMBH.

One of the most intriguing findings is the non-detection of strong [O III] emission combined with significant Balmer line emission (Hβ and Hγ) in the extended gas. This unusual combination could suggest that shock ionization dominates the ionization mechanisms in the extended nebula. Shocks, likely driven by powerful quasar winds, are accelerating and heating the gas, generating Balmer line emission while failing to fully ionize oxygen to produce [O III]. This ionization structure provides crucial insights into the role of mechanical feedback from the quasar, as it redistributes energy across the galaxy.

The velocity and dispersion maps further support this scenario, showing high-velocity (up to 2500 km/s) shocks expanding outward from the central quasar. The presence of such shocks implies that AGN feedback is not only shaping the gas dynamics but is also potentially regulating star formation within the host galaxy. The observed ionization and kinematics point to a complex interplay between the quasar-driven outflows and the host galaxy’s interstellar medium, where feedback mechanisms are both heating the gas and potentially suppressing future star formation.

These findings provide a crucial step toward understanding SMBH-host galaxy co-evolution at extreme mass and luminosity scales during the early universe. The detailed analysis of J0313-1806 offers a rare opportunity to study quasar-driven feedback in the most distant quasar known, providing direct evidence of how AGN outflows influence the galaxy’s gas and star formation. This work represents a key contribution to our understanding of how the first massive galaxies and black holes evolved during cosmic dawn.

Presenter: WOLF, Julien (Max Planck Institute for Astronomy)

Contribution ID: **51** Type: **Oral (onsite)**

Probing the link between dense environment and fast SMBH growth at high redshift

Thursday 21 November 2024 14:20 (20 minutes)

The large-scale environment is one of the key drivers of galaxy evolution, but the link with SMBH growth, especially at high redshift, is so far poorly understood. Massive SMBHs are thought to form in the peaks of the dark matter distribution of the early Universe, and dense and gas-rich regions at later cosmic times can provide the conditions for efficient SMBH growth. This scenario can be tested observationally with a two-fold approach by searching for overdensities of galaxies around luminous QSOs as close as possible to the epoch of SMBH formation, and investigating the AGN content of the density peaks of the high-redshift Universe, e.g. protoclusters. I will discuss some on-going activities that follow such lines of research. In particular, I will present the results of recent Chandra observations of two extremely gas-rich protoclusters at z=4, namely DRC and SPT2349, identified as strong overdensities of dusty star-forming galaxies (DSFGs). By comparing the AGN incidence in those structures with the AGN population in a sample of DSFGs in the field environment matched in L_FIR and stellar mass, we found a significant enhancement of AGN in high-redshift protoclusters. Interestingly, both protoclusters host in their central regions a luminous (Lbol~1e47 erg/s) and heavily obscured (NH~1e24 cm-2) AGN, with space densities higher by 3-5 orders of magnitude than what is found in the field environment. These objects represent a key phase of fast and efficient SMBH growth that will likely produce strong feedback, allowing the accreting SMBHs to reveal themselves as luminous optical QSOs at later cosmic times. I will also show preliminary results of an on-going work aimed to probe the large-scale (up to 8 Mpc) environment of a sample of 15 z>~6 QSOs using dedicated optical/IR observations with LBT and CFHT. The aim of this project is to obtain the first statistically robust view of the typical environmental properties of massive SMBHs at cosmic dawn by selecting Lyman-break galaxy (LBG) candidates at the same redshift of the central QSOs. Some of the targets have been already observed, and all of these appear to be surrounded by a number of LBGs in excess of the expectations from blank fields. These results support the existence of tight links between dense and gas-rich regions of the Universe, the formation of SMBHs, and their rapid growth at high redshift.

Presenter: VITO, Fabio (INAF - OAS Bologna)

Contribution ID: **52** Type: **Oral (onsite)**

Resolving Star Formation and Nuclear Activities in a Protocluster with JWST/NIRCam PaB Imaging

Thursday 21 November 2024 14:40 (20 minutes)

Understanding the interplay between galaxies and SMBHs has become a central theme in the latest research on galaxy formation and evolution. AGN feedback is thought to be the most reasonable solution to regulate star formation and match current observations in the modern hydrodynamic simulations. The hydrodynamic simulations report that studying solely luminous AGNs would not contribute to understanding AGN feedback as it only traces temporary AGN activities and its energy injection is fairly low compared with the total budget. Rather, they claim that examining low-luminosity AGNs in low accretion states is important for uncovering permanent quenching. This talk will show the results of JWST/NIRCam PaB narrowband imaging in the Spiderweb protocluster at z=2.16 (Shimakawa et al., 2024 in press and submitted), where one of the deepest Chandra X-ray image is available (T_exp=700ks). While NIR lines are useful for studying the properties of massive, dust-obscured galaxies than UV and optical lines, until JWST, there has been no suitable instrument for resolving them for high-z galaxies. We investigate PaB radial profiles of massive protocluster galaxies with and without low-luminosity X-ray AGNs, and then spatially resolve their star formation and AGN activities for the first time. Obtained PaB line images of non-X-ray members indicate significant star formation in the outskirts. In contrast, those of low-luminosity AGNs are dominated by point source components and star formation in host galaxies is significantly suppressed. Our results also show a great agreement with their passive natures independently derived from the X-ray-to-submm SED fitting (Shimakawa et al., 2024 MNRAS 528:3679). Considering their high stellar potential parameters, we conclude that their different PaB characteristics would be driven by the impact of AGN feedback.

Presenter: SHIMAKAWA, Rhythm (Waseda University)

Contribution ID: **53** Type: **Invited**

Quasar-Galaxy Co-Evolution from Wide-Field Surveys

Thursday 21 November 2024 15:30 (30 minutes)

In this talk I will give an overview of some of the exciting research in quasar-galaxy co-evolution that will be enabled by future wide-field imaging and spectroscopic surveys including the Vera C. Rubin Observatory Legacy Survey of Space Time (LSST), the Euclid mission as well as wide-field spectroscopic surveys with new facilities such as 4MOST and VLT-MOONS. The focus will be on understanding populations of obscured and reddened quasars as well as disentangling quasar and host galaxy emission using these datasets. I will showcase some pilot studies utilising imaging from HyperSuprimeCam and VISTA as well as spectroscopic data from SDSS and VLT-XShooter that demonstrate the promise of these future datasets. I will reflect on how ground-based surveys can provide a complementary view to JWST on the co-evolution of galaxies and their supermassive black holes across cosmic time.

Presenter: BANERJI, Manda (University of Southampton)

Contribution ID: **54** Type: **Oral (onsite)**

Machine Learning-based Search of High-redshift Quasars

Thursday 21 November 2024 16:00 (20 minutes)

High-redshift (z > 5) quasars provide effective probes for the study of galaxy evolution and cosmology, hence it is critical to obtain a large sample of high-redshift quasars to study the intergalactic medium, circumgalactic medium and the co-evolution of supermassive black holes and their host galaxies. Here we present a machine learning search for high-redshift (5.0 < z < 6.5) quasars using the combined photometric data from the DESI Imaging Legacy Surveys and the WISE survey. We discuss the imputation of missing values for high-redshift quasars, analyze the feature selections, compare different machine learning algorithms, and investigate the selections of class ensemble for the training sample. The 11-class random forest model can achieve a precision of 96.43% and a recall of 91.53% for high-redshift quasars for the test set. Using MUSE and DESI-EDR public spectra, we find that 14 true high-redshift quasars (11 in the training sample) out of 21 candidates are correctly identified for MUSE, and 20 true high-redshift quasars (11 in the training sample) out of 21 candidates are correctly identified for DESI-EDR. Additionally, we estimate photometric redshift for the high-redshift quasar candidates using random forest regression model with a high precision. We also demonstrate that the deeper images and more photometric measurements from the future imaging surveys such as CSST, RST, EST and LSST would significantly improve the performance of the random forest model. Utilizing the gravitational lensing effect, we estimate the quasar luminosity function at the faint end at 4 < z < 6.5.

Presenter: ZHANG, Huanian (Huazhong University of Science and Technology)

Contribution ID: **55** Type: **Oral (onsite)**

NEXUS: the North ecliptic pole EXtragalactic Unified Survey

Thursday 21 November 2024 16:20 (20 minutes)

NEXUS is a JWST Multi-Cycle (Cycles 3–5; 368 primary hrs) GO Treasury imaging and spectroscopic survey around the North Ecliptic Pole. It contains two overlapping tiers. The Wide tier (~400 arcmin2) performs NIRCam/WFSS 2.4–5 μm grism spectroscopy with three epochs over 3 years (final continuum sensitivity of 22.2 at F444W). The Deep tier (~50 arcmin2) performs high-multiplexing NIRSpec 0.6–5.3 μm MOS/PRISM spectroscopy for ~10, 000 targets, over 18 epochs with a 2-month cadence (epoch/final continuum sensitivity of ~27/29 at 2 μm). All epochs have simultaneous multi-band NIRCam and MIRI imaging (5σ final depths of ~28–29 in NIRCam and ~25 in MIRI). The field is within the continuous viewing zone of JWST, and is fully covered by the Euclid Ultra-Deep Field, with 0.9–2 μm deep Euclid spectroscopy and cadenced photometry to maximize synergy across wavelengths and science areas. NEXUS has three science pillars. First, with its massive and nearly complete (flux-limited) spectroscopic samples and deep photometry, it will perform efficient classification and physical characterization of galaxies and AGNs from z~1 to Cosmic Dawn. With the large contiguous area coverage, it will measure the spatial clustering and demography of the first galaxies and SMBHs at z > 6. Second, multi-epoch observations enable systematic time-domain investigations, focusing on z>3 transients and low-mass AGN reverberation mapping. Third, the comprehensive dataset will enable knowledge transfer to other legacy fields, create data challenges, and initiate benchmark work for future space missions. With rapid public releases of processed data and an open invitation for collaboration, NEXUS aims for broad and swift community engagement, to become a powerhouse to drive transformative advancements in multiple key science areas of astronomy.

Presenter: ZHUANG, Mingyang (University of Illinois Urbana-Champaign)

Contribution ID: **56** Type: **not specified**

discussion

Thursday 21 November 2024 16:40 (30 minutes)

Contribution ID: **57** Type: **not specified**

concluding remarks

Thursday 21 November 2024 17:10 (20 minutes)