# NERQUAM 31

## University of Rhode Island - 2023

### Schedule:

### 0900 – 0945: Breakfast and Refreshments

### 0945 – 0950: Welcome to URI:

Doug Gobeille
URI

### 0950 – 1010: News

Herman Marshall: Update on Rocket Experiment Demonstration of a Soft X-ray Polarimeter (REDSoX)
MIT Kavli Institute

Jonathan Trump: Update on recent JWST discoveries of high redshift AGN
UConn

### 1010 – 1125: First Session

Hugh Sharp (UConn) [1010 - 1025]

This work studies the accretion disk size of a 95 quasar sample in the Sloan Digital Sky Survey Reverberation Mapping (SDSS-RM) project, with continuum lags measured in Homayouni et al. (2019) between g and i-photometry bands. We explored this diverse and well characterized sample in search of connections between various quasar properties, and the measured continuum lag deviation from the values predicted by the Shakura & Sunyaev (1973) model. Similar to the results ofLi et al. (2021), we find that quasars with larger-than-expected continuum lags have lower optical luminosity, but additionally have lower X-Ray luminosity and black hole mass. This anti-correlation most favors the predictions of the Corona-Heated Accretion-disk Reprocessing model (CHAR; Sun et al. 2020), which would predict continuum-lags influenced by both light-crossing time as well as the thermal timescale, which is proportional to the square root of luminosity. In addition, our quasar sample exhibited a larger scatter in SS73 model discrepancy within $0.8<z<1.0$, a region in which the g and i lightcurves may be influenced by diffuse nebular contamination originating from the further out Broad-Line Region (BLR). While diffuse contamination has been confirmed in more detailed multi-band single target studies, finding larger lags influenced by the 3650 Angstrom Balmer Jump (Fausnaugh et al. 2016, Cackett et al. 2018), for our singular lag quasar sample, efforts to affirm that these lag discrepancies originated BLR contamination offered a null result. Future analysis on multi-band continuum-rm surveys will be required in order to determine how predominant the effects of diffuse BLR contamination is, specifically past the influence of the Balmer Jump alone.

## Fabio Pacucci (Harvard CfA) [1025 - 1040]

A SMBH of ~3 million solar masses was recently detected via dynamical measurements at the center of the dwarf galaxy Leo I. Standing ~2 orders of magnitude above standard scaling relations, this SMBH is hosted by a galaxy devoid of gas and with no significant star formation in the last ~1 Gyr. While a few over-massive central SMBHs are reported in nearby isolated galaxies, this is the first detected in a Milky Way satellite. We proposed that winds from a population of ~100 evolved stars within the Bondi radius of the SMBH produce a sizable accretion rate of $10^{-7}$ to $10^{-6}$ times the Eddington rate, typical of advection-dominated accretion flow mode. I will describe the predicted spectral energy distribution and discuss its observability. Additionally, I will briefly describe a new study that used the LCDM cosmological simulations ASTRID and Illustris TNG50 to investigate the assembly history of galaxies hosting over-massive SMBHs. We estimate that Leo I-like systems are rare but exist in simulations: they occur in ~0.005% of all over-massive systems. Our findings suggest that massive satellite infall and consequent tidal stripping in a group/dense environment can drive systems away from the standard black hole/host relations, causing them to become over-massive.

## Jonathan Mercedes Feliz (UConn) [1040 – 1055]

Active Galactic Nuclei (AGN) feedback is a crucial ingredient in galaxy evolution models to suppress star formation and quench massive galaxies. However, the physics of feedback mechanisms such as AGN-driven winds is still poorly understood. We present a suite of cosmological hydrodynamic “zoom-in” simulations of a z~2 massive galaxy from the Feedback In Realistic Environments (FIRE) project, which includes state-of-the-art multi-phase interstellar medium physics and a novel technique to model AGN-driven winds at high resolution. In previous work, we have shown that both positive and negative AGN feedback can coexist in galaxies, with positive triggering of star formation playing a minor role compared to the overall negative suppression of global galaxy growth. I will present some recent lessons learned from these simulations as well as their important implications for: (1) the transfer of AGN wind kinetic energy to the surrounding gas from 10 pc to circumgalactic medium scales, (2) the formation of dense stellar clumps in the presence of strong AGN winds, and (3) the impact of AGN winds on galaxy sizes and their observable properties.

## Kelly Whalen (Dartmouth College) [1055 – 1110]

Constraining the role of feedback in regulating black hole and galaxy growth is crucial to our understanding of the processes that have formed galaxy populations observed throughout cosmic time. For massive galaxies in particular, large-scale ejective feedback is a necessary ingredient for simulating the properties of observed galaxy populations. The energetics required to expel large amounts of star forming gas from galaxies typically suggest that AGN are the most likely culprits for quenching massive galaxies. However, it is also possible that feedback from extremely rapid and compact nuclear star formation is capable of driving high-velocity, ejective outflows from massive galaxies. Here, I present results from a physical model for a population of massive (1e11 Msun), intermediate-redshift (z ~ 0.5), compact (Reff ~ 100 pc), starburst (SFR ~ 1000 Msun yr-1 kpc-2) galaxies. These galaxies host large-scale, high-velocity outflows, and have little to no evidence for ongoing AGN activity, making them the perfect laboratories for probing stellar feedback at its most extreme. However, their space density has previously been unknown, making it difficult to constrain whether extreme, compact star formation is an important phase in shaping the majority of massive galaxies, or if it is a relatively rare event that happens in only the most extreme cases. Here, I will present our physical model for this population of extreme, compact starbursts, and discuss how we determine the timescale over which they would be targeted by our selection criteria to then calculate their intrinsic space density. It is possible that a fraction of some of the most extreme ULIRGs and post-starbursts might experience extreme nuclear star formation like this, but a majority of massive galaxies are likely formed via separate mechanisms.

Niranjan Chandra Roy (UConn) [1110 – 1125]

Unveiling the drivers of galaxy growth is one of the key science goals of Astrophysics this decade. When did the first galaxies form? How did the clumpy early galaxies evolve to the diversity of morphologies that we see today? What is the impact of feedback from massive stars and black holes on galaxy evolution? We investigate these questions with detailed synthetic observations of FIRE (Feedback In Realistic Environments) simulated galaxies at a range of redshifts. The FIRE simulations resolve the multi-phase interstellar medium of galaxies while capturing their cosmological environment and self-consistently reproduce a range of observed galaxy properties, providing a unique platform to produce synthetic IFU data for one-to-one comparisons to observations by JWST and other IFU surveys. We leverage the non-equilibrium chemistry solver CHIMES and the 3D Monte-Carlo line radiative transfer code RADMC-3D to model the emission, propagation, and absorption of spectral lines from the FIR to the UV regimes along with stellar emission and absorption, scattering, and thermal emission from dust grains. In my talk, I will present the details of this pipeline for producing mock IFU data cubes at different emission lines for FIRE galaxies, some recent results, and discuss ideas about how we could try to interpret such mock images/spectra to extract key physical information about the galaxies that can be then compared with the simulation. I will also share a roadmap to include AGN radiation in the pipeline to investigate the impact of AGN on galaxy spectra.

## 1125 – 1145: Coffee Break and Posters

## 1145 – 1215: Invited Talk

Dale Kocevski (Colby College)

The capabilities of JWST are now allowing us to measure the host demographics of AGN beyond cosmic noon and detect lower luminosity quasars out to the epoch of reionization. I will discuss recent AGN-related results from the CEERS Survey, including the discovery of low-luminosity, broad-line AGN at $z>5$ found with our NIRSpec observations. One of these sources is at $z=8.67$, making it the most distant AGN ever discovered. These sources are powered by black holes with masses of order $10^7$ Msun, making them the least-massive BHs known at high redshift. 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. I will also discuss the host properties of X-ray bright AGN at $3<z<5$, which we find to be located in massive, quiescent galaxies with undisturbed morphologies. The presence of AGN in passively evolving galaxies at $z>3$ is significant because a rapid feedback mechanism is required in most models and simulations to explain the growing population of massive quiescent galaxies observed at these redshifts. I will discuss the implications of these findings and what they tell us about the connection between SMBH growth and the emergence of the first generation of massive quiescent galaxies in the early universe.

## 1215 – 1315: Second Session

### Jaya Maithil (Harvard CfA) [1215 - 1230]

Title: Modified Prescription of Single-Epoch Hβ-based Mass for Quasars with Highly Accreting Black Holes

The mass and accretion rate are arguably the most fundamental properties of quasars. An accurate estimate of these physical properties is essential in quantifying the growth of the black holes, their evolution, and their impact on the host galaxies. A primary technique to measure the black hole mass employs the reverberation mapping (RM) of quasars, which is then extended via the radius–luminosity (R-L) relationship for the broad-line region to estimate masses based on single-epoch spectra. Recent RM campaigns show that the highest accretion rate objects have a systematically smaller broad-line region radius, 3-8 times smaller than predicted by canonical R-L relationships. An updated version of the R-L relationship includes the flux ratio of optical Fe II to Hβ (RFe) to correct the accretion rate bias. I will present the result of using this Fe-corrected R-L relationship to estimate the black hole mass and accretion rate parameters of quasars in a wide range of redshifts. Failure to use a Fe-corrected R-L relationship results in the Hβ-based mass overestimated by a factor of two, on average, and up to an order of magnitude for highly accreting black holes. Our results reinforce the connection between the dominant Eigenvector 1 parameter RFe and the accretion process.

### Logan Fries (UConn) [1230 – 1245]

Reverberation mapping has been successful in measuring the masses of quasars under the assumption that the gas in the broad-line region (BLR) is moving in orbits dominated by gravity. Recently, velocity-resolved reverberation mapping has unveiled a diversity of non-virial kinematics in the BLR, which puts pressure on the enterprise of black hole mass estimation. This is especially apparent in the case of the hyper-variable quasar, RM160, where the dramatic radial-velocity shifts have been interpreted as inflow onto the BLR. I will show velocity-resolved reverberation mapping of RM160. These results demonstrate how the high-cadence, long-duration, and multi-epoch time domain spectroscopy of SDSS-RM/BHM-RM is shedding new light on the detailed physics of the gas near luminous quasars.

### Annie Giman (Yale) [1245 – 1300]

The BAT AGN Spectroscopic Survey (BASS) is a large multiwavelength survey of hard X-ray-identified active galactic nuclei (AGN) in the nearby universe. We have identified a subset of obscured AGNs with atypical features, including spectral signatures of inner accretion disk reprocessing, variable line-of-sight absorption, ionized outflows, and extremely steep X-ray continua. Previous studies have found that, for some of these intermediately obscured atypical AGN (optical types 1.8 and 1.9), supermassive black hole (SMBH) masses derived from the standard H-alpha line in the optical have been up to an order of magnitude biased compared to those derived from stellar dispersion or the Pa-alpha line in the near-infrared (NIR). While obscured AGNs do not show line broadening in the optical, about a third do in the NIR because of less sensitivity to dust reddening. We present new NIR broad line measurements based on Palomar/TripleSpec data and SMBH mass estimations for a sample of intermediate-type obscured AGN, including measurements of the Br-gamma line in the K-band.

Tristan Weaver (Yale) [1300 – 1315]

We set out to examine the relationship between obscuration and luminosity by focusing on IRAS 09104+4109 — an X-ray luminous, ULIRG, CT-candidate quasar at z = 0.442. We present results from X-ray spectroscopic fitting in the rest frame band 0.8-100 keV including three novel epochs from NuSTAR. We have fit phenomenological spectral models and self-consistent, geometry-based models to the X-ray spectrum. Our goals are to determine if there is evidence for variability in line-of-sight obscuration column and to constrain the geometry of the obscurer in this quasar. Our models do not show a difference in luminosity between epochs, and adding variability to our models does not produce significant improvements in model fit; we conclude that IRAS 09104+4109 is not variable on the timescales observed. We also determine that at a line of sight column density log(NH)=23.6-24.2, IRAS 09104+4109 is likely non-CT. Our models suggest intrinsic, rest-frame, 2-10 keV luminosity log(L)>45. In our model without variability, we find a torus covering factor of approximately 0.82, and in the model with variability we find a torus covering factor of approximately 0.6. These covering factors are not consistent with extrapolation of covering factor from lower X-ray luminosities. The effect of covering factor on IR luminosity for IRAS 09104+4109 is considered and compared to those of other (U)LIRGs.

## 1315 – 1445: Lunch

There are numerous options for lunch available at the nearby Kingston Emporium off of Upper College Rd and Fortin Rd. Options include:

**Simply Thai**
**The Rhode House**
**International Pocket Cafe**
**Caliente Mexican Grill**
**Albie’s Place**
**Sedra Cafe**
**Providence Bagel**
**Subway**
**Peking Tokyo**

## 1445 – 1545: Third Session

### Herman Marshall (MIT Kavli Institute) [1445 – 1500]

I will show polarimetry results from IXPE observations of low frequency BL Lac objects (LBLs) and radio quiet AGN. The AGN are mildly polarized, when detected, a result of scattering in the corona of an accretion disk. The polarizations of LBLs have not yet been detected significantly, indicating that the X-ray spectra are dominated by Compton scattering of unpolarized photons such as produced by stars or the accretion disk.

### Rujuta Purohit (Dartmouth College) [1500 – 1515]

We present a multi-wavelength analysis of three candidate Active Galactic Nuclei (AGNs) in dwarf galaxies within the Boötes field. Using data from the Chandra X-ray Observatory, we find three X-ray luminous dwarf galaxies in the Boötes field. We compute the X-ray, mid-infrared, and [O III] luminosities and compare them to established relationships in the literature. We generate spectral energy distributions and fit templates to conclude that the MIR has contribution from an AGN. The best-fit star formation rates are unable to explain the observed X-ray luminosities of the candidates, confirming the existence of AGNs. We use various scaling relations to estimate the masses of the black holes and find that they are of the order of $10^5$ - $10^7$ M_solar. Thus, we find that these are strong candidates for IMBHs and can help us understand the formation and evolution of black holes.

### Claire Hinrichs (Dartmouth College / CfA) [1515 – 1530]

The Very Energetic Radiation Imaging Telescope Array System (VERITAS) is one of the world's most sensitive very-high-energy (VHE; E > 100 GeV) gamma-ray observatories. VERITAS is used to regularly monitor the VHE flux of select intermediate-frequency-peaked BL Lac objects (IBLs), including BL Lacertae itself. IBLs are typically only detected at VHE during flaring episodes, and their VHE emission mechanisms may differ from those of high-frequency-peaked BL Lac objects more commonly detected at VHE. In October-November 2022, VERITAS observed a long duration (~ 45 days) VHE flare from BL Lacertae for the first time. The initial detection of this flare triggered a multiwavelength observation campaign on the source. Scientific results from these multiwavelength observations of this BL Lacertae flaring event will be presented.

### Wystan Benbow (Harvard Smithsonian Astrophysical Observatory) [1530 – 1545]

Title: Status of VERITAS & Recent Highlights from its AGN Program

VERITAS is one of the world's most sensitive detectors of astrophysical very high energy (VHE; E > 100 GeV) gamma rays. This observatory began full-scale operations in 2007, and nearly 8,000 hours of its good-weather observations have been targeted on active galactic nuclei (AGN). VERITAS spectral and variability measurements, and accompanying broadband observations, are key probes of the underlying jet-powered processes in AGN. The status of the VERITAS and recent scientific highlights from its AGN program will be presented.

## 1545 – 1600: Coffee Break and Posters

## 1600 – 1700: Third Session

### Ryan Hickox (Dartmouth College) [1600 – 1615]

Title: The Kiloparsec Scale Influence of the AGN in NGC 1068 with SALT RSS Fabry-Perot Spectroscopy

We present Fabry-Perot (FP) imaging and longslit spectroscopy of the nearby Seyfert II galaxy NGC 1068 using the Robert Stobie Spectrograph (RSS) on the Southern African Large Telescope (SALT) to observe the impact of the central Active Galactic Nucleus (AGN) on the ionized gas in the galaxy on kiloparsec scales. With SALT RSS FP we are able to observe the Hα+[N II] emission line complex over a ~4 arcmin2 field of view. Combined with the longslit observation, we demonstrate the efficacy of FP spectroscopy for studying nearby Type II Seyfert galaxies and confirm the existence of kiloparsec scale ionized features with line ratios consistent with AGN activity using a larger field of view than previous observations by the TYPHOON survey. While these have been attributed to shocks, we put forward an alternate explanation for the kiloparsec scale ionization features. Using a toy model, we suggest the features may be understood as a light-echo from a burst of AGN activity ~2000 years in the past.

### Bren Backhaus (UConn) [1615 – 1630]

The emission lines of galaxies provide a wealth of information about galactic formation and their physical properties. One way to analyze emission lines is by comparing ratios of lines at similar wavelengths to gain information on the interstellar medium (ISM) conditions. Emission-line diagrams such as BPT, [OIII]/Hb vs [NII]/Ha, have been used at z~0 to separate active galactic nuclei (AGN) and star forming (SF) galaxies, but proven to be ineffective at z~2. Now with the launch of JWST we can further investigate AGN emission-line diagnostics at high redshifts (z>2). This work uses CEERS JWST NIRSpec and NIRCam Grism data to investigate the use of [OIII]/Hb vs [NeIII]/[OII] diagram (OHNO) at z>5 and finds that a redshift calibration to the AGN/SF line or new emission-line diagnostics are needed.

### Jason Young (UMass Amherst) [1630 – 1645]

Title: Halfway To the Peak

We present first results from the JWST cycle 1 program "Halfway to the Peak", which targets actively growing galaxies with a range of AGN contributions during the transitional period of z~0.6. During this era, cosmic star formation was ramping down from its peak at cosmic noon, but still three times higher than today. Our MIRI/MRS IFU spectra span the full MRS range from 5-28 microns, encompassing a rich suit of spectral diagnostics. Using these MRS data, we derive spatially resolved maps of numerous star formation indicators and shocked gas indicators, and unresolved indicators of black hole accretion. We discuss some of the novel data reduction techniques we developed in order to obtain the quality of reduced spectra presented.

Stephanie Podjed (Dartmouth College) [1645 – 1700]

Spectropolarimetry is a powerful tool that led to the AGN geometric unification scheme and continues to allow us to investigate AGN central regions. Blazars are AGN with a relativistic jet that is aligned with our line-of-sight and whose optical emission is usually dominated by non-thermal synchrotron emission, leading to a continuum linear polarization that is typically greater than a few percent. For other Type 1 AGN, such as quasars, the inclination angle is not well known and due to the direct quasar light, the polarization signal can be diluted, resulting in polarization levels less than a few percent. In this study, we present preliminary results on optical linear polarization percentage and position angle of a sample of southern hemisphere gamma-ray active and quiescent blazars in the redshift range 0.116 $<$ z $<$ 1.522, with a focus on FSRQs PKS 1510-089 and PKS 0637-75, to determine how the head-on orientation or the presence of a jet influences spectropolarimetric variations of blazars in the broad lines and continuum. The medium resolution (R $\sim$ 2000) optical spectropolarimetric data used for this study were obtained approximately bi-weekly from the Robert Stobie Spectrograph on the Southern African Large Telescope (SALT) in Sutherland, South Africa.

## 1700 – 1900: Informal Discussions at Shaidzon Brewery

Shaidzon Brewery is conveniently found nearly adjacent to Kingston Station at 141 Fairground Rd, West Kingston, RI 02892. Thursday night is **OPEN MIC NIGHT**, so bring your best!

There is seating both inside and outside and the weather is expected to be nice but cool in the low 60s.

*Thank you for attending* and we will see you next year for **NERQUAM 32**!