New England Regional Quasar Meeting 2015
Thursday, 4 June 2015
Room 104, Wilder Laboratory, Dartmouth College
https://www.dartmouth.edu/~hickox/NERQUAM/

The Dartmouth College Department of Physics & Astronomy is delighted to be hosting the New England Regional Quasar and AGN Meeting. This is the 25th annual NERQUAM and the first to be held at Dartmouth. This one-day meeting is held annually in the late spring, rotating between the six sponsoring institutions and occasional other sites with the aim of promoting interaction and collaboration between those working on various aspects of Active Galaxies and Quasars in and around the Boston area. It is always a relaxed and highly enjoyable meeting where students and established scientists can mingle and converse, and presenters can try out new and speculative ideas.

Lunch will be held at the Class of 1953 Commons, across the Green from Wilder Hall. Lunch vouchers can be purchased for $10 at registration.

We aim to present all talks on a single laptop. Please upload your talk to the laptop well in advance of your session.

Public Wifi is available under the SSID “Dartmouth Public”.

Local Organising Committee
Ryan Hickox ● Mackenzie Jones ● Chris Carroll ● McKinley Brumback ● Kevin Hainline ● Chien-Ting Chen ● Parker Gardner ● Raphael Hviding
## Oral Program

### 9:45 – 9:50
**Welcome and Introduction, Ryan Hickox, Dartmouth College**

### 9:50 – 11:00
**AGN Physics and the Central Engine** *(Chair: R. Hickox)*

<table>
<thead>
<tr>
<th>Speaker</th>
<th>Institution</th>
<th>Topic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Martin Elvis</td>
<td>CfA</td>
<td>The Wind and the Rain: Warm Absorbers, Infalling BELR clouds and X-ray Eclipses</td>
</tr>
<tr>
<td>Ana Glidden</td>
<td>MIT</td>
<td>CLiF AGN: A Clear View of the Inner Torus Wall?</td>
</tr>
<tr>
<td>Mason Keck</td>
<td>BU</td>
<td>NuSTAR and Suzaku X-ray Spectroscopy of NGC 4151: Evidence for Reflection from the Inner Accretion Disk</td>
</tr>
<tr>
<td>John Wardle</td>
<td>Brandeis</td>
<td>Getting the Angle on Quasars</td>
</tr>
<tr>
<td>Jianfeng Wu</td>
<td>CfA</td>
<td>Nature of Weak Emission-line Quasars: Unification with a Geometrically Thick Accretion Disk</td>
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<tr>
<td>Chien-Ting Chen</td>
<td>Dartmouth</td>
<td>The X-ray and Mid-IR Luminosities in Luminous Type 1 Quasars</td>
</tr>
</tbody>
</table>

### 11:00 – 11:30
**Coffee Break and Poster Session**
<table>
<thead>
<tr>
<th>Time</th>
<th>Session</th>
<th>Chair</th>
<th>Presenters</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>11:30 – 12:00</td>
<td><strong>Invited Review</strong> <em>(Chair: B. Wilkes)</em></td>
<td></td>
<td>Eilat Glikman</td>
<td>Middlebury</td>
</tr>
<tr>
<td>12:00 – 1:00</td>
<td><strong>AGN, Galaxies, and Surveys I</strong> <em>(Chair: B. Wilkes)</em></td>
<td></td>
<td>Carie Cardamone</td>
<td>Wheelock</td>
</tr>
<tr>
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<td></td>
<td>Andy Goulding</td>
<td>Princeton</td>
<td>The Hyper-Suprime Camera Survey: A New Window Into Black Hole Growth</td>
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<td></td>
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<td>Dale Kocevski</td>
<td>Colby</td>
<td>The Chandra X-UDS Survey</td>
</tr>
<tr>
<td></td>
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<td>Stefano Marchesi</td>
<td>Yale</td>
<td>The $z &gt; 3$ Sample in the Chandra COSMOS Legacy Survey</td>
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<td></td>
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<td>Hyewon Suh</td>
<td>CfA</td>
<td>Type 2 AGN Host Galaxy Properties in the Chandra COSMOS Legacy Survey</td>
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<td>Time</td>
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<td>1:00 – 2:00</td>
<td>Lunch, Class of 1953 Commons</td>
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<td>2:00 – 3:15</td>
<td>AGN, Galaxies, and Surveys II</td>
<td>Mar Mezcua</td>
<td>CfA</td>
<td>Growing Black Holes, From the First Seeds to AGN</td>
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<td>Kristina Pardo</td>
<td>Princeton</td>
<td>Searching for Low-Mass AGN to $z &lt; 1$</td>
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<td>Ai-Lei Sun</td>
<td>Princeton</td>
<td>Unveiling the Link Between Supermassive Black Holes and Galaxies</td>
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<td>Eric Roebuck</td>
<td>Tufts</td>
<td>Interpreting the IR SED of $z \sim 0.3 - 4$ IR-luminous Galaxies and AGN Using Hydrodynamic Simulations</td>
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<td>Christopher</td>
<td>Dartmouth</td>
<td>Photometric Redshifts and SEDs of WISE-selected Obscured Quasars</td>
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<td>DiPompeo</td>
<td>Dartmouth</td>
<td>Probing Quasars with the CMB</td>
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<td>Time</td>
<td>Session</td>
<td>Speaker</td>
<td>Affiliation</td>
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<td>3:15 – 4:00</td>
<td><strong>AGN Jets and Interactions with Hot Gas</strong> (Chair: A. Marscher)</td>
<td>Aneta Siemiginowska</td>
<td>CfA</td>
<td>Young Radio Sources – Status</td>
</tr>
<tr>
<td></td>
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<td>Dan Schwartz</td>
<td>CfA</td>
<td>X-rays Measure the Kinetic Flux of Quasar Jets on Scales of 100’s of kpc</td>
</tr>
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<td></td>
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<td>Paul Nulsen</td>
<td>CfA</td>
<td>Powering AGN at the Centers of Hot Atmospheres</td>
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<tr>
<td></td>
<td></td>
<td>David Roberts</td>
<td>Brandeis</td>
<td>The Abundance of X-Shaped Radio Sources: Implications for the Gravitational Wave Background</td>
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<tr>
<td>4:00 – 4:30</td>
<td><strong>Coffee Break and Poster Session</strong></td>
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<td>4:30 – 6:00</td>
<td><strong>Blazars</strong> (Chair: S. Jorstad)</td>
<td>Michael Malmrose</td>
<td>BU</td>
<td>The NIR to UV Spectral Energy Distributions of Gamma-Ray Bright Blazars</td>
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<td>Name</td>
<td>Institution</td>
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<tr>
<td>Manasvita Joshi</td>
<td>BU</td>
<td>Spectral Fitting Of Blazars With MUZORF</td>
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<tr>
<td>Wystan Benbow</td>
<td>CfA</td>
<td>Highlights from the VERITAS AGN Observation Program</td>
<td></td>
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</tr>
<tr>
<td>Mahito Sasada</td>
<td>BU</td>
<td>Shot Analysis of Kepler Blazar W2R 1926+42</td>
<td></td>
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<tr>
<td>Matteo Cerruti</td>
<td>CfA</td>
<td>A Hadronic Origin for Ultra-High-Frequency-Peaked BL Lac Objects</td>
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<td>Nicholas MacDonald</td>
<td>BU</td>
<td>One Epoch At A Time: Discovering Jet Structure In Blazars Through Radio Map Stacking</td>
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<tr>
<td>Anna Barnacka</td>
<td>CfA</td>
<td>Resolving the High Energy Universe with Strong Gravitational Lens- ing</td>
<td></td>
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</tbody>
</table>
Poster Program

Posters are displayed throughout the workshop in the coffee area.

<table>
<thead>
<tr>
<th>Name</th>
<th>Institution</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>Emmet Golden-Marx</td>
<td>BU</td>
<td>Tracing the Connection Between Bent, Double-Lobed Radio Sources and Galaxy Clusters: Optical Follow-Up for the High-Redshift CO-BRA Survey</td>
</tr>
<tr>
<td>Adela Habib</td>
<td>Middlebury</td>
<td>Spectral Energy Distribution of Red Quasars</td>
</tr>
<tr>
<td>Kevin Hainline</td>
<td>Dartmouth</td>
<td>A Tale of Two Narrow-Line Regions: Kinematics, Ionization Structure, and SED Modeling for a Local Pair of Merging Active Galaxies</td>
</tr>
<tr>
<td>Ryan Hickox</td>
<td>Dartmouth</td>
<td>X-ray Variability of a Candidate AGN in the Dwarf Starburst He 2-10</td>
</tr>
</tbody>
</table>
NERQUAM 2015 Oral Program Abstracts

The Wind and the Rain: Warm Absorbers, Infalling BELR clouds and X-ray Eclipses
Dr Martin Elvis | Harvard-Smithsonian Center for Astrophysics
melvis@cfa.harvard.edu

Abstract

Velocity resolved reverberation mapping (VRRM) has shown strong evidence for inflows in the broad emission line region (BELR) of active galactic nuclei (AGNs). This unexpected result is hard to reconcile with the need to lose angular momentum from accreting gas without forming an accretion disk. I suggest that cooling instabilities, induced by the varying UV and X-ray quasar continua in the semi-ubiquitous warm absorber (WA) outflows found in AGNs, lead to dense BELR clouds condensing out of the warm flow. These BELR clouds condense quickly (days \( \leq \) weeks), and will sometimes do so before the WA outflows reach escape velocity. Such condensations will not be accelerated further and will fall back on elliptical orbits and on a dynamical timescale (1 yr), producing an inflow that rains down toward the central black hole. However, the \( \square \) raindrops\( \square \) will be rapidly (months) destroyed by moving at Mach 30 with respect to the WA outflow. This rain of BELR clouds could produce the observed VRRM inflow signature, and can explain the narrow \( \square \) cometary \( \square \) tails of BELR clouds seen in X-ray eclipse observations. Some issues and tests of the quasar rain model are presented.

CLiF AGN: A Clear View of the Inner Torus Wall?
Ana Gildden | MIT
melvis@cfa.harvard.edu

Abstract

Coronal-Line Forest Active Galactic Nuclei (CLiF AGN) are a newly recognized type of AGN that have a remarkably large number of optical emission lines (up to 99), in particular strong (EW > 5 Å) forbidden high ionization lines (FHIL, e.g. [FeVII], [FeX], and [NeV]). Rose, Elvis, and Tadhunter (2015) suggest that the line emission of type 2 CLiF AGN is dominated by reflection from the inner wall of the obscuring region, so the strength of the FHILs is due to a specific viewing angle that gives us a maximal view of the far wall of the torus. Here we test the plausibility of this scenario. We developed a model of the torus as a cylinder of dust and gas exterior to an optically thick accretion disk and point-like continuum source. We have derived how the visible area of the inner wall changes with viewing angle. We then calculate the strength of [FeVII] \( \lambda 6087 \) emission for a number of intermediate angles (30°, 40°, and 50°). The results compare well with the observed luminosities of this emission line from six known CLiF AGN.

NuSTAR and Suzaku X-ray Spectroscopy of NGC 4151: Evidence for Reflection from the Inner Accretion Disk
Mason Keck | Boston University
keckm@bu.edu

Abstract

We present X-ray timing and spectral analyses of simultaneous 150 ks Nucleus Spectroscopic Telescope Array (NuSTAR) and Suzaku X-ray observations of the Seyfert 1.5 galaxy NGC 4151. We disentangle the continuum emission, absorption, and reflection properties of the active galactic nucleus (AGN) by applying inner accretion disk reflection and absorption-dominated models. With a time-averaged spectral analysis, we find strong evidence for relativistic reflection from the inner accretion disk. We find that relativistic emission arises from a highly ionized inner accretion disk with a steep emissivity profile, which suggests an intense, compact illuminating source. We find a preliminary, near-maximal black hole spin \( a > 0.9 \) accounting for statistical and systematic modeling errors. We find a relatively moderate reflection fraction with respect to predictions for the lamp post geometry, in which the illuminating corona is modeled as a point source. Through a time-resolved spectral analysis, we find that modest coronal and inner disk reflection flux variation drives the spectral variability during the observations. We discuss various physical scenarios for the inner disk reflection model, and we find that a compact corona is consistent with the observed features.
Getting the Angle on Quasars.

Prof John Wardle  |  Brandeis University
wardle@brandeis.edu

Abstract
Radio core dominance, the rest-frame ratio of core to lobe luminosity, has been widely used as a measure of Doppler boosting of a quasar’s radio jets and hence of the inclination of the central engine’s spin axis to the line of sight. However, the use of the radio lobe luminosity in the denominator (essentially to try and factor out the intrinsic power of the central engine) has been criticized and other proxies for the intrinsic engine power have been proposed. These include the optical continuum luminosity, and the luminosity of the narrow-line region. Each is plausible, but so far none has been shown to be clearly better than the others. We evaluate four different measures of core dominance using a new sample of 126 radio loud quasars, carefully selected to be as free as possible of orientation bias, together with high quality VLA images and optical spectra from the SDSS. We find that normalizing the radio core luminosity by the optical continuum luminosity yields a demonstrably superior orientation indicator. Also, by comparing the equivalent widths of broad emission lines in our orientation-unbiased sample to those of sources in the MOJAVE program, we can evaluate the relative contributions of disc emission and beamed emission from the jets. This work is the first step in constructing a more powerful tool to constrain the orientation of radio-loud quasars to the line of sight.

Nature of Weak Emission-line Quasars: Unification with a Geometrically Thick Accretion Disk

Dr Jianfeng Wu  |  Harvard-Smithsonian Center for Astrophysics
jianfeng.wu@cfa.harvard.edu

Abstract
I will report the recent progress on the X-ray studies of weak emission-line quasars (WLQs). We obtained new Chandra observations on 33 WLQs and found that about half of the WLQs are exceptionally X-ray weak. X-ray spectral analyses indicate strong intrinsic absorption for WLQs. We extend our previous proposed "shielding gas" model to explain the nature of WLQs, which involves a geometrically thick inner disk caused by unusually high Eddington accretion (e.g., a slim disk).

The X-ray and Mid-Infrared luminosities in Luminous Type 1 Quasars

Dr Chen Chien-Ting  |  Dartmouth College
ctchen@dartmouth.edu

Abstract
We study the correlation between the AGN mid-IR luminosity at rest-frame $6$ $\mu$m ($L_{6\mu m}$) and the rest-frame 2–10 keV luminosity ($L_X$) for a sample of 1,594 spectroscopically confirmed type 1 quasars collected from Bootes, XMM-COSMOS and Swift/SDSS. We show that when focusing only on the most luminous quasars ($L_{bol} > 10^{45} \text{ erg s}^{-1}$), the $L_X - L_{6\mu m}$ correlation deviates from the approximately linear relations found in local Seyfert galaxies and quasar samples with shallower X-ray flux limits. We find that the $L_X - L_{6\mu m}$ relation can be described by a two-slope relation in the log-log plane: $\log L_X = (0.85 \pm 0.03) \times \log L_{6\mu m} + 6.29 \pm 1.51$ for $\log L_{6\mu m} < 44.34$, and $\log L_X = (0.45 \pm 0.03) \times \log L_{6\mu m} + 23.92 \pm 2.31$ for $\log L_{6\mu m} > 44.34$. This result implies that estimations of the neutral gas column density for X-ray absorptions using the linear $L_X - L_{6\mu m}$ relation might be biased in luminous quasars.

Dust Reddened Quasars: A Transitional Phase in Quasar/Galaxy Co-Evolution

Dr Eliat Glikman  |  Yale university
eilat.glikman@yale.edu

Abstract
We recently identified a large population of dust-reddened quasars by matching radio sources detected in the FIRST survey to the 2MASS near-infrared catalog (F2M) and selecting sources with red topical-to-near-infrared colors. We find that dust-reddened quasars are intrinsically the most luminous quasars in the Universe. Further analysis suggests that red quasars represent an emergent phase in merger-driven quasar/galaxy co-evolution model where the obscured quasar is shedding its dusty shroud prior to becoming a "normal" quasar. We present an expansion of this sample to fainter flux limits with the UKIDSS Large Area Survey (LAS) First Data Release (DR1; 190 deg$^2$). The deeper K-band limit enables the discovery of more heavily reddened quasars at higher redshifts. We have identified 12 new obscured quasars, including at least two with $z > 2$ reaching lower intrinsic luminosities than were found by the F2M survey. We find that red quasars represent
Galaxy Zoo: Bars & the Secular Evolution of AGN

Prof Carie Cardamone  |  Wheelock College
CCardamone@wheelock.edu

Abstract

Many theories predict the importance of secular feeding of nuclear activity in AGN, some highlighting bar features that can drive gas towards the galactic center. However, a large number of studies have produced highly contradictory results in attempting to find clear connections between the presence of nuclear activity and bar features in galaxies. Galaxy Zoo provides statistically robust morphological classifications for galaxies from a large variety of surveys, including searching for presence of bar features. In the local Universe, $0.01 < z < 0.05$, using a volume limited sample of galaxies from the SDSS survey, we find that both the presence of an AGN and that of a large scale bar is closely tied to a galaxy’s integrated color and mass. While there is still a slight enhancement in the AGN fraction of barred vs unbarred galaxies in bins fixed by mass and color, there is no evidence that barred AGN have a higher accretion rate (as measured by $L_{\text{kin}} / M_{\text{BH}}$) when compared to unbarred AGN. Looking beyond the local universe, $0.2 < z < 1.0$, Galaxy Zoo combines the HST data from AEGIS, COSMOS and GOODS to search for galaxies for large scale bar features. Using X-ray data to detect evidence of AGN activity, the data shows that the AGN host galaxies show no significant enhancement in bar fraction or average bar-likelihood as compared to closely-matched inactive galaxies. Taken all together, these results show that large-scale bars are not likely to play a large role in the fueling of moderate luminosity AGN since $z \sim 1$.

The Hyper-Suprime Camera survey: a new window into black hole growth

Dr Andy Goulding  |  Princeton University
goulding@astro.princeton.edu

Abstract

Despite significant progress in our understanding of black hole (BH) demography, questions still remain for how BH growth is triggered, particularly in the most luminous AGN. Host galaxy morphology is likely a key ingredient. I will present first-look results on AGN and galaxy demographics extracted from the new 1400 deg$^2$ Hyper-Suprime Camera survey. By harnessing the exceptional quality and high-resolution imaging coupled with unprecedented seeing ($<0.5''$) across such a wide area, we have begun to investigate the average morphologies of IR and X-ray selected luminous AGN down to a limiting magnitude of $i < 26$ mags in the HSC survey.

The Chandra X-UDS Survey

Prof Dale Kocevski  |  Colby College
dale.kocevski@colby.edu

Abstract

I will provide an overview of the upcoming X-UDS survey, a Chandra XVP program to image the Subaru-XMM Deep/UKIDSS Ultradeep Survey (SXDS/UDS) field. The survey aims to shed light on SMBH growth in two key epochs: Cosmic Dawn at $z > 7$ and Cosmic Noon at $z \approx 2$. At high redshifts, the survey will extract information on the nature of the first luminous accreting BHs in the Universe at $z > 7$ by cross-correlating large-scale fluctuations in the cosmic X-ray background (CXB) and the cosmic infrared background (CIB). This will provide a unique insight into populations of the early BH seeds and galaxies that are inaccessible to current direct studies and yield information of fundamental importance to Cosmology. At moderate redshifts ($z \approx 2$), we will use our deep observations to identify a sizable number of Compton-thick AGN via their X-ray spectral signatures and determine their obscuration and host galaxy properties. I will provide a summary of these science goals, as well as a status update for the survey and a timeline for the release of derived data products by the X-UDS team.

The $z > 3$ sample in the Chandra COSMOS Legacy survey

Stefano Marchesi  |  Yale University
stefano.marchesi@yale.edu

Abstract

In this talk, I present the first scientific highlights from the $z \geq 3$ AGN sample of the Chandra COSMOS Legacy survey. I first show the X-ray and optical properties of the $\approx 170$ sources (the largest X-ray selected sample in this range of redshift on a contiguous field), then I talk about the LogN-LogS and the space densities of the sample, and how these results can put constraints on the predictions of different phenomenological models. Finally, I show the different evolution between unobscured and obscured space densities.
Type 2 AGN host galaxy properties in the Chandra COSMOS Legacy survey

Hyewon Suh | Harvard-Smithsonian Center for Astrophysics
hyewon.suh@cfa.harvard.edu

Abstract
We present the host galaxy properties of a large sample of ~3000 X-ray selected Type 2 Active Galactic Nuclei (AGN) in the Chandra COSMOS Legacy Survey to investigate the connection between black hole accretion and host galaxy. The COSMOS Legacy survey reaching X-ray fluxes of $2 \times 10^{-16}$ (cgs) in the 0.5-2 keV band, bridges the gap between large area shallow surveys and pencil beamed one. Making use of the existing multi-wavelength photometric data available for 96.6% of the sources, COSMOS Legacy survey provides a uniquely large sample to derive host galaxy properties. We perform a multi-component modeling from far-infrared (500 um) when available to UV (1500 Å) using a 3-component fitting (nuclear hot dust torus, galaxy and starburst components) for obscured AGN. Galaxy templates are from the stellar population synthesis models of Bruzual & Charlot (2003), nuclear hot dust templates are taken from Silva et al. (2004), and starburst templates are from Chary & Elbaz (2001) and Dale & Helou (2002). Through detailed analysis of the broad-band spectral energy distribution, we derive the stellar masses and the star formation rates of the host galaxy as well as the nuclear and galaxy contribution at each frequency. We study the dependence of host galaxy properties on redshifts, luminosities, and black hole accretion rates to infer the growth history of galaxies and black holes and we compare with a sample of inactive galaxies.

Growing black holes, from the first seeds to AGN

Dr Mar Mezcua | Harvard-Smithsonian Center for Astrophysics
mar.mezcua@cfa.harvard.edu

Abstract
Supermassive black holes of $10^{10}$ solar masses already existed when the Universe was less than ~1 Gyr old. To reach this mass in such a short time, they should have started as seed intermediate-mass black holes (IMBHs) of $10^3$–$10^6$ solar masses and grow via accretion and mergers. Such IMBHs are the missing link between stellar and supermassive black holes and they should be present in the nucleus of low-mass galaxies and in the halos of galaxies that have undergone a minor merger event. I will present the discovery of an IMBH of $4 \times 10^5 M_\odot$ located in the arm of a nearby spiral galaxy and with a radio jet as powerful as those of supermassive black holes. I will also show the finding of a population of IMBHs up to $z \sim 1.5$ based on the stacking analysis of low-mass galaxies in the COSMOS survey, which is the largest survey with a complete, deep, multiwavelength dataset.

Searching for Low-Mass AGN to $z < 1$.

Kristina Pardo | Princeton University
kpardo@astro.princeton.edu

Abstract
Understanding Active Galactic Nuclei (AGN) evolution is critical to understanding galaxy evolution. The strong correlation between the masses of the supermassive black hole (SMBH) and that of the galaxy bulge suggests some connection between galaxy evolution and AGN. However, there is so far very little data on the smallest AGN in the universe. These AGN provide a direct link to the predecessors of the AGN we see today, and allow us to better constrain their evolution. Using HST and the NEWFIRM Medium Band Survey in the AEGIS field, we have selected galaxies with $M_{\text{star}} \lesssim 10^9 M_\odot$ and analyzed their X-ray properties using the deep 200–800ks Chandra data to robustly identify AGN candidates. We have identified several seemingly low-mass AGN with $M_{\text{bh}} \lesssim 10^5 M_\odot$, and use these data to place constraints on the luminosity and space density distributions of low mass AGN to $z < 1$. 
Unveiling the link between supermassive black holes and galaxies.

Ai-Lei Sun  |  Princeton University
aisun@astro.princeton.edu

Abstract
Active galactic nuclei (AGN) feedback has been proposed to explain various phenomena in galaxy evolution, including the tight correlation between supermassive black hole mass and galactic bulges, as well as the inefficient star formation in massive galaxies. I will talk about two different approaches to investigate this link between black holes and their host galaxies. First, whether the black hole correlates better with the galactic bulge (as traced by stellar velocity dispersion) or the dark matter halo (by circular velocity) encrypts the origin of the correlation. With a new sample of megamaser galaxies with precise black hole mass and HI circular velocity measurements, we found that black hole mass correlates better with the stellar bulge than the dark matter halo. This could be due to the black hole interacting with the baryonic mass in the galaxy through physical mechanisms (e.g., AGN feedback). Second, the most direct form of AGN feedback is galactic outflows, which suppresses star formation by disturbing the gas. I will present ALMA and Magellan observations of massive outflows in local luminous quasars. These observations confirm that luminous AGN can impact the dynamics and phase of the galactic medium, and reveal the complex multi-phase and multi-scaled nature of the feedback phenomenon. Lastly, I will discuss the prospects of AGN feedback studies in the era of large scale optical imaging surveys, e.g. HSC and LSST.

Interpreting the IR SED of $z \sim 0.3 - 4$ IR-luminous Galaxies and AGN Using Hydrodynamic Simulations

Eric Roebuck  |  Tufts University
eric.roebuck@tufts.edu

Abstract
We use three-dimensional hydrodynamical galaxy merger simulations to further investigate the nature of a sample of 342 24$\mu$m-selected (ultra) luminous infrared galaxies at $z \sim 0.3 - 4$. All of our sources have low-resolution Spitzer/IRS spectra – the largest such sample outside the local universe. These spectra allow us to determine that our sample consists of a mixture of star forming galaxies, AGN, and composites. We compare the IRS spectra and broadband photometry including Herschel far-IR data with theoretical SEDs based on gadget hydrodynamic merger simulations additionally processed through the sunrise radiative transfer code. Our model library spans a range of gas rich isolated discs and mergers, including those with artificial AGN boost/suppression, that appear to well represent our sample. We find broad agreement between empirically derived infrared AGN fractions to best fit input AGN fractions from the simulations. Additionally we compare observed morphology to the merger stage implied by SED fitting to our simulations for a subset of 112 galaxies.

Probing Quasars With the CMB

Dr Mike DiPompeo  |  University of Wyoming
mdipompe@uwyo.edu

Abstract
The CMB backlights the entire sky, and CMB photons are gravitationally lensed as they pass massive structures in the Universe. This lensing signature can be detected with the current generation of all-sky CMB maps, and used to probe the dark matter halos of galaxies and quasars at high redshift. Using this technique and IR/optical selection methods, I will discuss the halo masses of obscured and unobscured quasars and the implications of such studies for quasar unification models.

Young Radio Sources - status

Dr Aneta Siemiginowska  |  Cfa
asiemiginowska@cfa.harvard.edu

Abstract
I will give a short status summary report from the 5th workshop on Giga-Hertz Peaked Spectrum Radio Sources which I’m going to attend next week. The workshop will be held in Rimini on May 27–29. The discussion will include the radio-to-gamma-ray observational status with some theoretical aspects of the evolution of radio sources.
X-rays measure the kinetic flux of quasar jets on scales of 100’s of kpc.

Dan Schwartz  |  Smithsonian Astrophysical Observatory
das@cfa.harvard.edu

Abstract

X-rays provide a direct means to estimate the kinetic power of jets on scales of 100’s of kpc. From a Chandra survey of radio jets, we find enthalpy fluxes typically \( (1 - 10) \times 10^{46} \text{ erg s}^{-1} \). This is the same order, or even larger, than the bolometric radiation of the host quasar. This is consistent with recent calculations showing that quasars can accrete at rates grossly higher than Eddington, easing the problem of formation of high mass quasars in the early universe. The median of the distribution of the results gives bulk Lorentz factors 6–12 and jet lengths 100–400 kpc, values slightly smaller than are often quoted as typical.

Powering AGN at the centers of hot atmospheres

Dr Paul Nulsen  |  Harvard-Smithsonian Center for Astrophysics
pnulsen@cfa.harvard.edu

Abstract

The empirical case for “radio mode” AGN feedback in cool core galaxy clusters is now strong. In galaxy clusters where the gas would otherwise be cooling and forming stars copiously, radio outbursts from a central AGN are able to quench the cooling and so limit the star formation rate to a relative trickle. The details of this process are the subject of much debate. In this talk I will focus on how the thermal state of the hot gas on scales much larger than the Bondi radius can determine the fuel supply to the AGN. I will argue that a wide range of observational evidence, from the radio to the X-ray, together supports the case that the gas is thermally unstable and that the AGN are powered mainly by accreting cooled hot gas.

The Abundance of X-Shaped Radio Sources: Implications for the Gravitational Wave Background

Prof David Roberts  |  Brandeis University
roberts@brandeis.edu

Abstract

Coalescence of super massive black holes (SMBH’s) in galactic mergers is potentially the dominant contributor to the low frequency gravitational wave background (GWB). It was proposed by Merritt & Ekers (2002) that X-shaped radio galaxies are signposts of such coalescences, and that their abundance might be used to predict the magnitude of the gravitational wave background. In Roberts et al. (2015) we present radio images of all 52 X-shaped radio source candidates out of the sample of 100 selected by Cheung (2007) for which archival VLA data were available. These images indicate that at most 21% of the candidates might be genuine X-shaped radio sources that were formed by a restarting of beams in a new direction following a major merger. This suggests that fewer than 1.3% of extended radio sources appear to be candidates for genuine axis reorientations (“spin flips”), much smaller than the 7% suggested by Leahy & Parma (1992). Thus the associated gravitational wave background may be substantially smaller than previous estimates. These results can be used to normalize detailed calculations of the SMBH coalescence rate and the GWB.
The NIR to UV Spectral Energy Distributions

Michael Malmrose | Boston University
mmalmros@bu.edu

Abstract

of Gamma-Ray Bright Blazars

In the small fraction of active galactic nuclei (AGN) classified as blazars, one may occasionally observe relatively unprocessed radiation from the accretion disk. In the spectral energy distribution (SED) this produces a feature in the optical-UV portion of the spectrum known as the big blue bump (BBB). In Blazars, however, the relative strength of emission from synchrotron radiation is still significant in this region of the electromagnetic spectrum, complicating direct measurements of the BBB luminosity. Decoupling the portion of the SED produced by synchrotron radiation from that produced by the accretion disk can be accomplished through the use of spectropolarimetric observations. The spectral index, $\alpha_s$, of the synchrotron emission is revealed from observations of the polarized flux spectrum of a blazar spanning from $\lambda = 4000$-7000 in the observer’s frame. The BBB emission is then obtained by fitting a two component model of the form $F_{\nu} = A \nu^{-\alpha_s} + B \nu^{-\alpha_{BBB}}$ to the full spectrum and fixing $\alpha_{BBB}$, the spectral index of the BBB, to -1/3. By deconstructing the spectra this way for $\gamma$-ray bright blazars insight can be gained into the stability of the BBB over the course of several years as well as provide clues to any wavelength dependence of the polarized emission.

Spectral Fitting Of Blazars With MUZORF

Dr Manasvita Joshi | Boston University
mjoshi@bu.edu

Abstract

We use the multi zone radiation feedback (MUZORF) model of Joshi, Marscher, and Boettcher (2014) in the internal shock scenario to study the spectral state of 3C 279 observed in the pre-Fermi era in early 2006 and that of OJ287 observed in the post-Fermi era in late 2008. We employ the MUZORF model to reproduce the high state of 3C 279 and OJ287. The model includes the contribution of various seed photon fields external to the jet in an anisotropic and time-dependent manner. In the case of 3C 279, we find that our model is able to reproduce the spectral high state successfully provided that the seed photon field is accounted for in an anisotropic manner, the emission region is placed outside of the broad line region (BLR), and the contribution of the dusty torus (DT) has been accounted for. The successful model is a combination of the synchrotron self Compton (SSC) process and the external Comptonization (EC) of the DT photons that reproduces spectral high state of 3C 279 observed in January 2006. On the other hand, in the case of OJ287, the successful model implies the dominance of the SSC process over EC with the emission region placed well outside the BLR and deep within the DT.

Highlights from the VERITAS AGN Observation Program

Dr Wystan Benbow | Harvard-Smithsonian Center for Astrophysics
wbenbow@cfa.harvard.edu

Abstract

The VERITAS array of four 12-m imaging atmospheric-Cherenkov telescopes began full-scale operations in 2007, and is one of the world’s most sensitive detectors of astrophysical VHE (E>100 GeV) gamma rays. Observations of active galactic nuclei (AGN) are a major focus of the VERITAS Collaboration, and more than 50 AGN, primarily blazars, are known to emit VHE photons. Approximately 3000 hours have been devoted to the VERITAS AGN observation program and roughly 150 AGN are already observed with the array. These observations have resulted in 34 detections, most of which are accompanied by contemporaneous broadband observations, enabling a more detailed study of the underlying jet-powered processes. Recent highlights of the VERITAS AGN observation program, and the collaboration’s long-term AGN observation strategy, will be presented.
Shot Analysis of Kepler Blazar W2R 1926+42

Dr Mahito Sasada  |  Boston University
sasada@bu.edu

Abstract
Blazars show rapid and violent variabilities, which timescales are often less than a day. We studied intraday variations by applying a shot analysis technique to Kepler monitoring blazar of W2R 1926+42. We obtained a mean profile calculated from 195 rapid variations. The mean profile of rapid variations shows three components; one is a sharp structure distributed within ±0.1 day of the peak, and the others are slow-varying components. This spiky-peak component reflects features of rapid variations directly. The profile of peak component shows an exponential rise and decay of which timescales are different, 0.042 and 0.059 days respectively. This component is too sharp to represent a standard function which is often used in blazar variations. This asymmetric profile at the peak is difficult to be explained by a simple variation of the Doppler factor by changing a geometry of the emitting region. This result indicates that rapid variations of the object arise from a production of high-energy accelerated particles in the jet.

A hadronic origin for ultra-high-frequency-peaked BL Lac objects
Matteo Cerruti  |  Harvard-Smithsonian Center for Astrophysics
matteo.cerruti@cfa.harvard.edu

Abstract
Current Cherenkov telescopes have identified a population of ultra-high-frequency peaked BL Lac objects (UHBLs), also known as extreme blazars, that exhibit exceptionally hard TeV spectra. Although one-zone synchrotron-self-Compton (SSC) models have been generally successful in interpreting the high-energy emission observed in other BL Lac objects, they are problematic for UHBLs, necessitating very large Doppler factors and/or extremely high minimum Lorentz factors of the emitting leptonic population. In this context, I have investigated alternative scenarios where hadronic emission processes are important, using a newly developed (lepto-)hadronic numerical code to systematically explore the physical parameters of the emission region that reproduces the observed spectra while avoiding the extreme values encountered in pure SSC models. In this talk I will first introduce the basis of hadronic modeling of blazar emission, and then present its application to UHBLs.

One Epoch At A Time: Discovering Jet Structure In Blazars Through Radio Map Stacking
Nicholas MacDonald  |  Boston University
nmacdon@bu.edu

Abstract
Blazars are among the most luminous objects in the sky, exhibiting flares across the electromagnetic spectrum on timescales ranging from months, to days, and even minutes. The origin of the highest-energy flares from within the jet of a blazar remains an open question. In an effort to further explore the innermost parsec-scale regions of a relativistic jet, MacDonald et al.2015 (in preparation) have begun the process of stacking radio maps obtained with the Very Long Baseline Array (VLBA) of a sample of blazars that have exhibited prominent flaring behavior. Each stacked map is carefully constructed from data collected over the course of seven years as part of the VLBA-BU-BLAZAR program at a radio frequency of 43 GHz, creating images with unprecedented dynamic range, sensitivity, and angular resolution. The stacking is done in all three Stokes parameters creating maps that highlight both the total and polarized intensity of each jet. These maps will be presented, revealing previously undetected jet structures, including clear jet spine-sheath polarization morphologies. Spine-sheath jet structure is a key component in a new theoretical model of blazar variability proposed by MacDonald et al. 2015 (ApJ, in press). This model explains a sub-set of the high-energy flares detected by the Fermi space telescope, and a brief review of this model will also be given.
Resolving the High Energy Universe with Strong Gravitational Lensing

Dr Barnacka Anna  |  Cfa
abarnacka@cfa.harvard.edu

Abstract
Gravitational lensing is a potentially powerful tool for elucidating the origin of gamma-ray emission from distant sources. Cosmic lenses magnify the emission and produce time delays between mirage images. Gravitationally-induced time delays depend on the position of the emitting regions in the source plane. Temporal resolution at gamma-ray energies can be used to measure these time delays, which, in turn, can be used to resolve the origin of the gamma-ray flares spatially. As a prototypical example of the power of lensing combined with long, uniformly sampled light curves provided by the Fermi satellite, we investigated the spatial origin of gamma-ray flares from PKS 1830-211. For two flaring periods, the emission is consistent with origination from the core and for the other two, the data suggest that the emission region is displaced from the core by more that 1.5 kpc.

NERQUAM 2015 Poster Program Abstracts

Tracing the Connection Between Bent, Double-Lobed Radio Sources and Galaxy Clusters: Optical Follow-Up for the High-Redshift COBRA Survey

Emmet Golden-Marx  |  Boston University
emmetgm@bu.edu

Abstract
Galaxy clusters are unique laboratories for exploring galaxy formation and evolution. Though few galaxy clusters have been spectroscopically confirmed beyond a redshift of $z \sim 1$, this number is increasing due to several detection methods including observing regions with a high density of galaxies in the optical and IR regimes, detecting the hot intracluster medium with X-ray observations, and measuring the Sunyaev-Zel’dovich effect. We employ a promising method for discovering high-redshift galaxy clusters that uses radio observations of AGN as cluster tracers. Specifically, we use bent, double-lobed radio sources, known often to reside in nearby clusters, as markers for distant galaxy clusters. Here, we present results from the high-redshift COBRA (Clusters Occupied by Bent Radio AGN) survey, using Spitzer IRAC observations of 653 bent, double-lobed radio sources with hosts too faint to be detected in the SDSS. Since the host galaxies for these radio sources are usually luminous giant ellipticals, the lack of SDSS detections means they are at $z > 0.7$. We have begun deep follow-up optical observations using the 4.3 m Discovery Channel Telescope and have determined from these optical observations that approximately 50% of the observed fields are overdense, and thus good cluster candidates. From these observations, we have created optical-IR color magnitude diagrams to estimate the redshifts of our cluster candidates by identifying the red sequences. The distribution of galaxies on the red sequence can be used to limit galaxy formation models by estimating when star formation ceases. Additionally, we plan to probe the effects of AGN on galaxy and cluster evolution.
Spectral Energy Distribution of Red Quasars
Adela Habib | Middlebury College
ahabib@middlebury.edu

Abstract
This project extends the previous study of Eddington ratios and supermassive black hole (SMBH or BH) masses of 87 dust-reddened quasars in the optical to mid-infrared wavelengths found by Glikman et al. (2012). Previously, we measured the black hole Eddington ratios using bolometric corrections from Richards et al. (2006). Our results showed diversity in our sample; most red quasars accrete close to the Eddington rate of ~ 1. However, some of our quasars accrete below the Eddington rate. To test the bolometric corrections as good estimates for dust-reddened quasars’ bolometric luminosities, we study total energy output of these quasars in optical to mid-infrared (MIR) wavelengths. We get the bolometric luminosity as the area under the best-fit model for the multiwavelength spectra. Out results on a subset of seven quasars in this sample show that bolometric luminosities from multiwavelength spectra are significantly different (p < 0.0001**) from bolometric luminosities using bolometric correction. Based on a seven quasar sample, we conclude that using bolometric corrections, we underestimate the bolometric luminosity for dust-reddened quasars. Future work on all the quasars in this sample should be conducted to test these results.

A Tale of Two Narrow-Line Regions: Kinematics, Ionization Structure, and SED Modeling for a Local Pair of Merging Active Galaxies
Dr Kevin Hainline | Dartmouth College
kevin.n.hainline@dartmouth.edu

Abstract
Active galactic nuclei (AGNs) are capable of ionizing gas in regions ranging from parsecs to tens of kiloparsecs, and emission from these extended photoionized regions can be crucial in understanding the history of individual AGNs. We explore the gas ionization and kinematics, as well as the spectral energy distribution for two nearby galaxies in a merger, J181611.72+423941.6 and J181609.37+423923.0 (J1816A and J1816B, z ≈ 0.04), two moderate luminosity AGNs which host vastly different narrow-line regions. Using spatially-resolved optical spectroscopy, we confirm the existence of a 10-kpc-scale ionization cone with velocities of ±300 km s⁻¹ (σ ∼ 200 – 300 km s⁻¹) in J1816A and compact (1-2 kpc) undisturbed emission in J1816B. We also model the spectral energy distributions for these objects, and compare multiple common indicators for AGN luminosity. While multiple measurements of the AGN luminosity agree for J1816B, the integrated flux for the full extended emission line region in J1816A is an order of magnitude larger than what is observed from the nucleus of the galaxy, well in excess of what would be expected from the infrared flux. XMM-Newton observations for the pair demonstrate a strong X-ray flux for J1816A, in agreement with the extended narrow-line emission. These results demonstrate the importance in accounting for extended emission when measuring the luminosity of AGNs, especially in merging galaxies where more extend gas is available to ionize in the line of sight to a powerful AGN.

X-ray Variability of the Candidate AGN in the Dwarf Starburst Galaxy Henize 2–10
Prof Ryan Hickox | Dartmouth College
ryan.c.hickox@dartmouth.edu

Abstract
We study the long-term X-ray variability of the nuclear point source in the nearby dwarf galaxy Henize 2–10. He 2–10 has shown evidence for a candidate accreting supermassive black hole (SMBH) of mass ~10⁶ M☉, representing a potential new environment for SMBHs that may have implications for the process of “seed” SMBH formation. Analyzing data spanning 14 years from ASCA, Chandra, and XMM-Newton (Whalen et al. 2015), we find that the hard component of the X-ray emission varies by approximately an order of magnitude over 10 years, consistent with the behavior of well-studied AGN.