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Talk: Highlights from VERITAS observations of active galactic nuclei"

Abstract: VERITAS is an array of four atmospheric Cherenkov telescopes, sensitive to very-high-energy (VHE; E > 100 GeV) gamma-ray photons. Since the beginning of scientific operations in 2007, it has detected more than 20 extra-galactic sources in the VHE sky. In this talk I will present an overview of the VERITAS results on active galactic nuclei, with a particular emphasis on the most recent results.

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Talk: Spectral Modeling of Successive Outbursts in the Blazar PKS 0208-512: Location, Mechanism and Other Implications

Abstract: The flat spectrum radio quasar (FSRQ) PKS 0208-512 underwent three outbursts at the optical-near-infrared (OIR) wavelengths during 2008-2011. The second OIR outburst did not have a gamma-ray counterpart despite being comparable in brightness and temporal extent to the other two. We model the spectral energy distribution of PKS 0208-512 during those three flaring episodes to show: i) Distance to the location of the emitting region ~ 2 parsec and ii) Variations in the Compton dominance parameter by a factor of ~4 --- which may result in the anomalous outburst --- can be relatively easily accounted for by moderate variations in the magnetic field strength or the location of the emission region. Since such variations appear to be rare among FSRQs, we propose that the radial distance dependence of the magnetic field and external photon fields are identical.

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Talk: The Halo Occupation Distribution of X-ray-Bright Active Galactic Nuclei: A Comparison with Luminous Quasars

Abstract: We perform halo occupation distribution (HOD) modeling of the projected two-point correlation function (2PCF) of high-redshift (z ~ 1.2) X-ray-bright active galactic nuclei (AGN) in the XMM-COSMOS field measured by Allevato et al. (2011). The HOD parameterization is based on low-luminosity AGN in cosmological simulations. At the median redshift of z\~1.2, we derive a median mass of $1.02^{+0.21}_{-0.23}\times10^{13}$ $M_{\odot}$ for halos hosting central AGN and an upper limit of ~10% on the AGN satellite fraction. Our modeling results indicate (at the 2.5σ level) that X-ray AGN reside in more massive halos compared to more bolometrically luminous, optically-selected quasars at similar redshift. The modeling also yields constraints on the duty cycle of the X-ray AGN, and we find that at z~1.2 the average duration of the X-ray AGN phase is two orders of magnitude longer than that of the quasar phase. Our inferred mean occupation function of X-ray AGN is similar to recent empirical measurements with a group catalog and suggests that AGN halo occupancy increases with increasing halo mass. We project the *XMM*-COSMOS 2PCF measurements to forecast the required survey parameters needed in future AGN clustering studies to enable higher precision HOD constraints and determinations of key physical parameters like the satellite fraction and duty cycle. We find that $N^2/A \sim 5\times10^6$ deg^{-2} (with N the number of AGN in a survey area of A deg^2) is sufficient to constrain the HOD parameters at the 10% level, which is easily achievable by upcoming and proposed X-ray surveys.

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Talk: A correlation between star formation rate and average black hole accretion in star-forming galaxies

ABSTRACT: I will present the results of recent studies on the coevolution of galaxies and the supermassive black holes (SMBHs) using Herschel far-infrared and Chandra X-ray observations in the Boötes survey region. For a sample of star-forming galaxies, we find a strong correlation between galactic star formation rate and the average SMBH accretion rate in star-forming galaxies. Recent studies have shown that star formation and AGN accretion are only weakly correlated for individual AGN, but this may be due to the short variability timescale of AGN relative to star formation. Averaging over the full AGN population yields a strong linear correlation between accretion and star formation, consistent with a simple picture in which the growth of SMBHs and their host galaxies are closely linked over galaxy evolution time scales.

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Talk: Star Formation in Dust-Rich Quasars

Abstract:With the Herschel Space Telescope, we have discovered a population of dust-rich broad-emission-line quasars (DBQs) at $0.5 < z < 3.5$. They open a unique window to study the star formation environment in the peak of black hole accretion phase, quasars. I will provide a brief summary of my recent work on the SED studies of this population, and talk about their implications in constraining the black hole accretion rate and star formation rate (SFR) in such systems. I will conclude with the potential of X-ray observations for the DBQ population.

Andy Goulding

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Title: On the origins of IR dust features observed in Compton-thick AGN

Abstract: I will discuss the results of a recent study exploring the origins of mid-IR dust extinction in all bona-fide Compton-thick AGN using Spitzer-IRS spectroscopy. Unified AGN models predict that the dusty torus should produce strong silicate absorption features in heavily obscured systems; however, we find that only a minority of nearby Compton-thick AGN have strong Si-absorption features. Further, Compton-thick AGN hosted in low-inclination angle galaxies exhibit only a narrow-range in Si-absorption (S_9.7~0-0.3), which is consistent with that predicted by clumpy-torus models. On the basis of the IR spectra and additional lines of evidence, we conclude that the dominant contribution to the observed mid-IR dust extinction is dust located in the host galaxy (i.e., due to disturbed morphologies; dust-lanes; galaxy inclination angles) and not necessarily from a compact obscuring torus surrounding the central engine.

Kevin Hainline
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Talk: The NLR Size - IR Luminosity Relationship: An Upper Limit on the Size of the Narrow-Line Region?

Abstract: We examine the spatial extent of the narrow-line regions (NLRs) of a large sample of local active galaxies. While we see a shallow slope in the relationship between NLR size and [OIII] luminosity (L[OIII]), we also explore how the NLR size scales with a more direct measure of instantaneous AGN power using mid-IR photometry from WISE. IR emission probes warm to hot dust near the central black hole and so, unlike L[OIII], it does not depend on the properties of the NLR. We calculate a power-law relationship between NLR size and 8 micron luminosity (L8μm) that is significantly steeper than that observed for NLR size and L[OIII]. We find that the size of the NLR goes approximately as $L8\mu m^{1/2}$, as expected from the simple scenario of constant-density clouds illuminated by a central ionizing source. We further see tentative evidence for a turnover at the high luminosity end of the relationship between NLR size and L8μm, and propose that we are seeing a limiting NLR size of 10 − 20 kpc, beyond which the availability of gas to ionize becomes too low. We find that L[OIII] is proportional to $L8\mu m^{1.4}$, consistent with a picture in which the [OIII] luminosity is dependent on the volume of the NLR. Together, these results indicate that high-luminosity quasars have a strong effect in ionizing the available gas throughout their host galaxies.

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Abstract: The Global mm-VLBI Array is the highest resolution telescope currently open for proposals. Operating at 3 mm and with two sessions per year, we can achieve angular resolutions of the order 40 micro-arcseconds. Here, I present preliminary results from a survey of Fermi-LAT detected gamma-ray active sources. Two of the most active and perennially interesting sources are BL Lac and OJ 287, both of which have exhibited recent (and in the case of BL Lac, current) flaring activity. As has been previously reported, OJ 287 appears to have completely changed the direction of its jet (by ~100 degrees). 3 mm images appear to confirm this interpretation whilst also showing additional complicated structural variability and ~15 degree PA swing within 6 months, coinciding with the flare. BL Lac is currently undergoing an historic outburst and was the subject of a Target of Opportunity global 3 mm VLBI observation in February this year. Though interpretation is still ongoing, complicated structural variability, unresolved at lower frequencies is detected.

Svetlana Jorstad

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Poster: The Gamma-ray Activity of the high-Z Quasar 0836+710 S.G.

Abstract: The Fermi LAT detected an increase in gamma-ray activity of the quasar 0836+710 (z=2.17) in Spring 2011 that culminated in a sharp gamma-ray flare at the end of 2011 when the source reached a flux of $1.4e^{-6}$ phot/s/cm^2 at 0.1-200 GeV. We monitor the quasar at optical wavelengths in photometric and polarimetric modes and with the VLBA at 43 GHz. The optical brightness of the quasar increased by ~0.5 mag in R-band and the degree of polarization rose by up to 30% during the highest gamma-ray state. We have identified in the VLBA images a strong superluminal component that emerged from the core during the enhanced gamma-ray activity. We present the results of a correlative analysis of variations at different wavelengths along with the kinematic parameters of the parsec scale jet. We discuss the location of the high gamma-ray emission in the relativistic jet, as well as the emission mechanisms responsible for gamma-ray production.

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Talk: Orientation/obscuration Effects in the Spectral Energy Distributions of High-z 3CRR sources

Abstract: One way to select AGN samples that are unbiased by the effects of orientation/obscuration is low-frequency radio emission. Here we study a complete, 178 MHz radio flux-limited, orientation unbiased sample of 3CRR sources with high-redshift ($1 < z < 2$). At these redshifts the radio luminosities of the 3CRR sources are high ensuring that all sources in the sample are AGN. The sample includes 19 quasars, 3 intermediate, mildly-obscured sources ($NH \sim 10^{\wedge 22}$-23 $cm^{\wedge -2}$), and 16 galaxies, half (8) of which are most likely Compton thick. We have recently studied the Chandra X-ray (Wilkes et al. 2013) and Spitzer IR (Leipski et al. 2009, Haas et al. 2008) properties of the high-z 3CRR sample and their dependence on orientation (provided by the radio-core dominance). We extend these studies by compiling the full (radio-to-X-ray) spectral energy distributions (SEDs) by supplementing Chandra and Spitzer data with data from the literature, and astronomical databases. I will present the diversity of Spectral Energy Distributions (SEDs) found among the high-z 3CRR sources and use PCA to study the relative importance of orientation and other central engine parameters (L/Ledd, black hole mass) on the SED appearance. I will compare our PCA results with the results of PCA applied to other samples: the PG quasar sample with little/no obscuration (Boroson & Green 1992) and the mildly obscured sample of red 2MASS AGN (Kuraszkiewicz et al. 2009).

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Poster: Through the Ring of Fire: Numerical Simulations of Blazar Variability

Abstract: Blazars exhibit flares across the electromagnetic spectrum. The majority of flares observed in gamma-rays tend to be highly correlated with flares detected in the optical, however, a small subset of gamma-ray flares appear to occur in isolation with no variability detected in the other wave bands. These orphan gamma-ray flares challenge current models of blazar variability which are unable to reproduce this type of behavior. I present a new theoretical model to explain such gamma-ray flares. In this model, a blob consisting of a power-law distribution of electrons propagates relativistically along the jet axis of a blazar and passes through a synchrotron emitting ring of electrons representing a shocked portion of a jet sheath. This ring supplies a source of seed photons which are then inverse-Compton scattered by the electrons in the moving blob. As the blob approaches the ring, the photon density in the co-moving frame of the blob increases, resulting in a gamma-ray flare that then dissipates as the blob passes through and then moves away from the ring. The model includes the effects of radiative cooling, and a spatially varying magnetic field. Support for the plausibility of this model is provided by observations of an isolated gamma-ray flare which was correlated with the passage of a superluminal knot through the inner jet of quasar PKS 1510-089 (Marscher et al. 2010). Synthetic light-curves produced by this new model are fit to the observed light-curves from this event.

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Abstract: We studied a peculiar X-ray source detected in the Chandra-COSMOS survey at z=0.359. CID-42 is the only source in the survey which clearly shows two optical sources (in the HST/ACS image) embedded in the same galaxy. Civano et al. 2010 and 2012 showed that one source is a bright active galactic nucleus (AGN), while the other is probably a star-forming region in the center of the galaxy. CID-42 was imaged in the X-rays using both *XMM-Newton* and *Chandra* ACIS-I observations. The X-ray spectra show a rare Ka line inverted P-Cygni profile, i.e. a redshifted absorption component and an emission component. Redshifted absorption lines are usually explained as high velocity inflows of ionized material very close to the active black hole. CID-42 absorption feature showed a considerable variability in the line energy peak, implying rapid changes of velocity and ionization state of the infalling material. In this talk I will present the results of a new *XMM-Newton* single long ($\simeq$130 ks) observation obtained to perform an accurate modelization of the absorption line. The results show that the absorption feature observed between 2003 and 2007 is not present in 2012 observation; on the other side a new absorption feature appeared at the energy range of about 7.5 keV (rest frame), suggesting an intriguing combination of inflow/outflow material.

Alan Marscher
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Talk: Turbulence as a Key Ingredient in Blazar Variability

Abstract: Multi-wavelength light curves of gamma-ray bright blazars reveal strong correlations across wavebands, yet striking dissimilarities in the details. The linear polarization tends to be highly variable in both degree and position angle, which implies that the magnetic field is turbulent. The author's Turbulent Extreme Multi-Zone (TEMZ) model renders emission from a blazar jet in terms of turbulent plasma crossing a standing conical shock in the "core" seen on millimeter-wave VLBA images. This presentation compares multi-waveband light curves and polarization variations of blazars, e.g., BL Lac, with simulated light curves produced by the TEMZ code. Although the randomness inherent in both turbulence and the code preclude exact reproduction of a given observed light curve, the characteristics of the model results agree with many of the properties of real blazars.

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Talk: Preheating by Cluster Central Radio Galaxies

Based on the relationship between radio power and jet power for cluster central radio galaxies measured locally, we have estimated the average jet power for a sample of 685 galaxy clusters in the redshift range $0.1 < z < 0.6$ in the area covered by the NRAO VLS Sky Survey. The correlation between radio power and cluster X-ray luminosity is weak, so that the average jet power of 3e44 erg/sec exceeds the power radiated in about half the clusters in the sample. A conservative estimate of the total energy deposited since $z = 2$ amounts to more than 1 keV per particle, enough to account for observed departures from self-similar scaling in clusters. Thus radio galaxies may affect the energetics of galaxy clusters as a whole.

Andreas Rauch
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Talk: A new method of constraining the orientation of radio-loud quasars on kpc scales.

Abstract: There are many cases where it is useful to know the orientation of a radio source. There are also various orientation indicators, such as projected linear size, radio core dominance, bent structure and the Laing-Garrington effect. These are weak indicators by themselves, but by combining them we can construct a much sharper tool.

We have used the projected linear size and the radio core dominance from a nearly complete sample of quasars with redshifts up to 3.5, together with Monte-Carlo simulations to construct a tool that is applicable to individual quasars, and generates a probability distribution, p(theta), for the orientation to the line of sight. In some parts of parameter space, p(theta) is quite peaked, giving useful constraints on source orientation.

As a byproduct of this work, we have also determined the intrinsic size distribution for radio loud quasars, and how it changes with cosmic epoch.

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Poster 1: Bayesian Methods in Sherpa.
Abstract: Bayesian Framework for modeling the high energy astrophysics data has been implemented in Sherpa, a modeling and fitting application in CIAO. Sherpa is written in Python and the latest version can be installed and used with Python 2.7. We describe the concept of models with priors, the MCMC options for exploring the posterior probability distributions, and available algorithms for hypothesis testing and model selection. The methods correctly account for the Poisson nature of high energy astrophysics data from space-based X-ray and gamma-ray missions such as Chandra or Fermi. In most situations the modeling has to account for instrumental effects characterized by a probability of detecting photons of a given energy at a particular detector channel, or a particular location on the detector. We provide variety of examples based on the high energy data with ready to use recipes. Some future directions and potential linking with other Python packages will also be presented.

Poster 2: What did we learn from Chandra, XMM-Newton & Fermi-LAT about
the High Energy Emission of Young Radio Sources?

Abstract: Giga-Hertz Peaked Spectrum (GPS) and Compact Steep Spectrum (CSS) radio sources comprise a large population of compact objects with radio emission fully contained within the innermost regions of the host galaxy (< a few kpc). Spectral and kinematic age measurements indicate their young age (typically < thousands years and in some cases < a few hundred years). These sources provide the important insights to the initial phase of the jet formation, radio source growth, source evolution and the jet impact on the ISM in the very central regions of the host galaxy. Our group has obtained Chandra and XMM-Newton observations for a large sample of these sources over several observing cycles. Our most recent Chandra observations targeted Low Radio Power Compact Sources (LLC) and Compact Symmetric Objects (CSO) associated with the nuclear regions of nearby galaxies. A sub-sample of the CSO contains young sources with measured kinematic ages within 100-3000 years. Here we highlight the results of the X-ray observations and also discuss the Fermi-LAT studies of the quasars present in our Chandra X-ray GPS/CSS sample.

John Wardle

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Talk: Testing the iC/CMB model for X-ray emitting kpc-scale jets: are the de-projected lengths of the jets “too long” ?

Abstract: In the iC/CMB model for the X-ray emission from kpc-scale jets, it is generally found to be necessary that the jets are still significantly relativistic on these scales with Doppler factors in the range 5-20. However, such high velocities may not be compatible with those found in other studies of kpc-scale jet velocities. A second worry is that large Doppler factors require that the jets must be oriented at rather small angles to the line of sight. When deprojected, some of the jets appear to be uncomfortably long when compared to the whole population of radio sources.

We can now study the size problem in some detail, based on the work of Andreas Rauch (Brandeis) who has determined the intrinsic size distribution of radio-loud quasars, and how it changes with cosmic epoch. He has also developed new methods to constrain their orientation to the line of sight. We will give a preliminary report on applying these to two samples of interest: (1) the MOJAVE survey, where superluminal motion sets rigorous additional constraints on orientation, and (2) the XJET compilation, where we can test whether or not the deprojected jets are “too long.”

Belinda Wilkes
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Talk: Revealing the heavily-obscured AGN population of High Redshift 3CRR Sources with Chandra X-ray Observations.

Abstract: Chandra and multi-wavelength observations of a complete, flux-limited sample of 38 high-redshift ($1<z<2$), low-frequency selected (and so unbiased in orientation) 3CRR radio sources reveals a significant (21%) population of Compton-thick active galaxies and an unobscured fraction of 0.5. Both numbers are large when compared with estimates from X-ray, optical and IR surveys at such high luminosities. The quasars have high radio core-fraction, high X-ray luminosities (log Lx ~ 45-46) and soft X-ray hardness ratios (HR ~ -0.5) indicating low obscuration. The NLRGs have lower core-fraction, lower X-ray luminosities (log Lx ~ 43-45) and mostly hard X-ray hardness ratios (HR > 0) indicating obscuration (log Nh ~ 22-24 /cm^2). About half the NLRGs have soft X-ray hardness ratios and/or high [OIII] emission line to X-ray luminosity ratio suggesting obscuration by Compton thick (CT) material so that scattered nuclear or extended X-ray emission dominates (as in NGC1068).These properties and the correlation between obscuration and radio core-fraction are consistent with orientation-dependent obscuration as in Unification models. The ratios of unobscured to Compton-thin ($22 <$ log Nh(int) < 24.2) to CT (log Nh(int) > 24.2) is 2.5:1.4:1. When interpreted in terms of a simple unification model, this indicates a 60 degree half-opening angle for the disk/torus and a CT disk of half-angle 12 degrees. We conclude that many NLRGs have intrinsic absorption 10-1000x higher than indicated by their X-ray hardness ratios, and their true Lx values are 10--100x larger than the hardness-ratio absorption corrections would indicate.

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Poster Title: Analysis of Spectral Energy Distributions of Gamma-Ray Emitting Blazars

Abstract: We present a sample of spectral energy distributions (SEDs) at multiple epochs for blazars confirmed by the Fermi Gamma-Ray Space Telescope to be sources of gamma ray emission. The blazars selected are from our on-going monitoring program of 36 objects. The SEDs include data from the Fermi LAT, Swift XRT and UVOT, the Perkins Telescope at Lowell Observatory, and a number of other ground-based facilities. The SEDs are constructed for various states of activity. With such data compiled on multiple objects, we are able to statistically study the relationships between spectral indices at the different frequency regimes. By analyzing these relationships, as well as changes in the peaks of the synchrotron and the inverse Compton components, we seek to identify differences between emission models at both quiescent and flaring states of gamma-ray blazars. We find some striking trends in the spectral index relationships that theoretical models should reproduce.

Jianfeng Wu

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Title: X-ray Emission Enhancement of Highly Radio-loud Quasars at z > 4

Abstract: We present a systematic study of the X-ray and multiwavelength properties of a sample of 17 highly radio-loud quasars (HRLQs) at z > 4 with sensitive X-ray coverage from new Chandra and archival Chandra, XMM-Newton, and Swift observations. Our HRLQ sample represents the top ~5% of radio-loud quasars in terms of radio loudness. We found that our HRLQs have an X-ray emission enhancement over HRLQs at lower redshifts (by a typical factor of ~3), and this effect, after controlling for several factors which may introduce biases, has been solidly estimated to be significant at the 3-4 sigma level. HRLQs at z=3-4 are also found to have a similar X-ray emission enhancement over z < 3 HRLQs, which supports further the robustness of our results. We discuss models for the X-ray enhancement's origin including a fractional contribution from inverse Compton scattering of cosmic microwave background photons.