NERQUAM 2011 ABSTRACTS

Keynote Talks:

Ed Moran (Wesleyan U.)

Title: Intermediate-Mass Black Holes in the Milky Way's Backyard

Intermediate-mass black holes hold important clues regarding the origin of the black-hole "seeds" that formed at earlier epochs and the subsequent co-evolution of massive black holes and their host galaxies. In this talk I describe our efforts to obtain an objective census of IMBHs in the local universe and the results of some follow-up work we have carried out on IMBH candidates from our survey.
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Reshmi Mukherjee (Barnard College)

TeV Blazars: A view from VERITAS

Observations of astrophysical objects in the TeV band are sensitive probes of highly energetic processes occurring in these sources. The majority of the active galaxies detected at TeV energies are blazars, sources where we view the jet nearly along its axis. TeV and multi-wavelength observations of blazars help us to better understand the mechanisms of ultra-relativistic jet production by supermassive black holes, and constrain models of particle acceleration in blazar jets. This talk will summarize recent observational results on TeV blazars, specially those made with the VERITAS Cherenkov telescope array in Southern Arizona. Some recent work on GeV-TeV blazar populations will also be presented.
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Contributed Talks:

Carie Cardamone (MIT)

Title: Galaxy Zoo: The Connection between AGN Activity and Bars in Late Type Galaxies

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Suchetana Chatterjee (Yale)

Title: The Halo Occupation Distribution of Active Galactic Nuclei

We investigate the halo occupation distribution of low luminosity active galactic nuclei (AGN) using a state-of-the-art cosmological hydrodynamic simulation that self-consistently incorporates the growth and feedback of supermassive black holes and the physics of galaxy formation (DiMatteo et al.\ 2008). We show that the mean occupation function can be modeled as a softened step function for central AGN and a power law for the satellite population. The satellite occupation is consistent with a weak redshift evolution and a power law index of unity. The number of satellite black holes at a given halo mass follows a Poisson distribution. We also show that the conditional luminosity function (CLF) of

the central AGN follows a log-normal distribution with the mean increasing and scatter decreasing with increasing redshifts. We analyze the light curves of individual AGN and show that the peak luminosity of the AGN has a tighter correlation with halo mass compared to instantaneous luminosity. We also compute the CLF of satellite AGN at a given central AGN luminosity. We do not see any significant correlation between the number of satellites with the luminosity of the central AGN at a fixed halo mass. The radial distribution of AGN inside halos follows a power law at all redshifts with a mean index of -2.33 \pm 0.08. Incorporating the environmental dependence of supermassive black hole accretion and feedback, our formalism provides a theoretical tool for interpreting current and future measurements of AGN clustering.
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Ritaban Chatterjee (Yale) [Poster]

Title: Similarity of the Optical-IR and Gamma-ray Time variability of the Fermi Blazars

We present the time variability properties of a sample of six blazars, AO 0235+164, 3C 273, 3C 279, PKS 1510-089, PKS 2155-304, and 3C 454.3, at optical-IR frequencies as well as gamma-ray energies. These observations were carried out as a part of the Yale/SMARTS program during 2008-2010 that has followed the variations in emission of the bright Fermi-LAT-monitored blazars in the southern sky with closely-spaced observations at BVRJK bands. We find that the optical-near IR variability properties are remarkably similar to those at the gamma-ray energies. The power spectral density (PSD) functions of the R-band variability of all six blazars are fit well by simple power-law functions with negative slope such that there is higher amplitude variability on longer timescales. No clear break is identified in the PSD of any of the sources. The average slope of the PSD of R-band variability of these blazars is similar to what was found by the Fermi team for the gamma-ray variability of a larger sample of bright blazars. This is consistent with leptonic models where the optical-IR and gamma-ray emission is generated by the same population of electrons through synchrotron and inverse-Compton processes, respectively. The prominent flares present in the optical-IR as well as the gamma-ray light curves of these blazars are predominantly symmetric, i.e., have similar rise and decay timescales, indicating that the long-term variability is dominated by the crossing time of radiation or a disturbance through the emission region and not by the acceleration or energy-loss timescales of the radiating electrons. For the blazar 3C 454.3, which has the highest-quality light curves, the total energy output, the ratio of gamma-ray to optical energy output, and the gamma-ray vs. optical flux relation differ in the six individual flares observed between 2009 August and December. This indicates that the location and/or mechanism of their generation are different. Location of a large gamma-ray outburst in 3C 454.3 is identified in the jet at ~18 pc from the central engine. This poses strong constraints on the models of high energy emission in the jets of blazars.
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Francesca Civano (CfA)

Title: The high-z AGN COSMOS universe

Multi-wavelength identification campaigns from medium deep and deep X-ray surveys with XMM and Chandra have opened a new perspective in the study of the high-redshift (z>3) AGN population. However, samples sizes have been quite limited because large area surveys have been too shallow, and the deep survey areas are too small. For the first time, were able to provide sizable samples of AGN with luminosities above logLx=43.5. We present the properties of the largest sample (72 sources) of X-ray selected z>3 AGNs, from the Chandra COSMOS survey. This sample defines the space density and

evolution of the z>3 X-ray selected AGN population. With 9 sources, we well sample the z>4 population, and the z>5 population is beginning to emerge with a 2 source sample plus a candidate at z=6.8. The results are compared with predictions from XRB synthesis models and semi-analytic models of galaxy formation.
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Manel Errando (Columbia)

Title: New results from quasar observations in the GeV band

Recent gamma-ray observations of flat spectrum radio quasars (FSRQs) by Fermi and ground based gamma-ray telescopes have revealed new characteristics of their gamma-ray emission. I will briefly describe the discovery of gamma-ray emission from PKS 1222+216 (4C +21.35) at E > 100 GeV during a flare in June 2010, where a flux doubling time of 10 minutes was observed. This is the first time that sub-hour variability is seen in flat spectrum radio quasars. In addition, spectral analysis of bright detected blazars in the GeV range with Fermi reveals spectral breaks in bright FSRQs. The spectral breaks have been recently interpreted as evidence for internal absorption of GeV photons by pair production with low energy photons from the broad line region. I will review the implications of the discovery of sub-hour variability and GeV spectral breaks on the location of the gamma-ray emitting region in quasars and our current understanding of the mechanisms responsible for gamma-ray emission. Finally, I will describe the VERITAS observation program on these objects.
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Dan Evans (CfA and Elon University)

Title: Panchromatic Observations of the Nuclei of z<0.5 3CRR Radio Galaxies: Implications for Feeding, Feedback, and Black Hole Spin

We present a radio through X-ray study of the nuclei of 3CRR radio galaxies at z<0.5. This unique data set allows us to explore accretion and feedback free from orientation bias, and to elucidate the role of spinning black holes in powering AGN. We answer three key questions:

(1) What is the origin of X-ray emission?

We show that the X-ray emission from low-excitation radio galaxies is dominated by a parsec-scale jet and shows no evidence for a torus. High excitation radio galaxies, on the other hand, are dominated by luminous accretion disks, and rarely show evidence of relativistically broadened Fe K lines.

(2) How does accretion take place?

By estimating the kinetic jet power, we show that Bondi accretion of the hot IGM can power the majority of LERGs, but not the most powerful of these outbursts (see talk by B. McNamara). The Bondi paradigm fails altogether for HERGs.

(3) How are jets powered?

We next consider models for extracting jet power from rotating black holes. We demonstrate that both the jet power and time evolution of radio-loud AGN fit into a model in which black hole spin varies from retrograde to prograde with respect to the accreting material.

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Eilat Glikman (Yale)

Title: The Reddest Quasars: A Transitional Phase in Quasar/Galaxy Co-Evolution

I present the results of a survey for dust-reddened quasars in a radio-selected sample using the FIRST and 2MASS surveys that has identified 130 such objects. This is the largest complete sample of red quasars spanning a broad range of redshifts and extinctions ($0.1 < z < 3$; $E(B-V) < 1.5$). I argue that dust-reddened quasars complete a missing piece of the merger-driven model for quasar/galaxy co-evolution. These object appear to represent a transitional phase between completely obscured accretion and UV-luminous, unobscured quasars. I use this sample to constrain the lifetime of this transitional phase and the fraction of quasars missed in optically-selected samples because of reddening and extinction.
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Doug Gobeille (Bennington College)[Poster]

Title: A Meta-Survey Analysis of Quasars in the high redshift universe

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Jedidah Isler (Yale)[Poster]

Title: SMARTS Optical Spectroscopy of the Blazar 3C 454.3

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Svetlana Jorstad, A.Marscher, I.Agudo, and B.Harrison (Boston U.)

Title: Kinematics of the Parsec-Scale Jet of the Quasar 3C454.4 during Gamma-ray outburst in December 2009

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Erin Kara (Barnard/Columbia)

Blazar Counterparts for Low-Latitude Unidentified Sources: 1FGL J2015.7+3708 and 1FGL 2027.6+3335

Previous studies in the Cygnus region proposed blazar counterparts for 1FGL J2015.7+3708 and 1FGL 2027.6+3335. Now, the analysis of 31 months of Fermi-LAT data reveals that the sources are variable, supporting the hypothesis of extragalactic origin of the gamma-ray emission. We present here the associations for 1FGL J2015.7+3708 and 1FGL J2027.6+3335 based on correlated variability between gamma-ray and radio light curves. We produce gamma-ray light curves from the LAT using the Fermi ScienceTools and obtain radio light curves at 15 GHz taken with the 40-m telescope at the Owens Valley Radio Observatory (OVRO). Simultaneous variability is seen in both bands for the two blazar candidates. The resulting spectral energy distribution shows a broad Inverse Compton component. Lastly, we resolve a third steady gamma-ray source in the region with spectral characteristics similar to

known LAT pulsars.
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Britt Lundgren (Yale)

Title: The New Largest Quasar Dataset: SDSS-III BOSS

Abstract: In the first year of survey operations, the SDSS-III Baryon Oscillation Spectroscopic Survey (BOSS) detected more quasars in the redshift range $2.2<z<3$ than all of the known quasars in this range to date (Ross et al. 2011). One of the of the primary goals of this 5-year survey is to precisely measure the baryon acoustic oscillations in the Lyman-alpha forest using the full target sample of 150,000 $z>2.2$ quasars, but a wide range of ancillary quasar and IGM investigations will also be possible with this new large dataset. I will briefly describe some of the novel techniques in quasar target selection that have allowed for the successful detection of ~15 quasars per square degree in a redshift range and color-space plagued by stellar contamination. I will also summarize a few of the science projects made possible with these data, including my own efforts to produce and analyze a new, large catalog of metal quasar absorption lines covering the redshift range $0.3<z<3.5$.
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Michael Malmrose (Boston U.)

Title: The Detection of Hot Dust in the Infrared Spectra of Gamma-Ray Bright Blazars

A possible source of γ-ray photons observed from the jets of blazars is inverse Compton scattering by relativistic electrons of infrared seed photons from a hot, dusty torus in the nucleus. We use observations from the Spitzer Space Telescope, along with archival data from the Sloan Digital Sky Survey(SDSS), and the Two Micron All Sky Survey (2MASS), to search for signatures of such dust in the infrared spectra of four γ-ray bright blazars, the quasars 4C 21.35, CTA102, and PKS 1510–089, and the BL Lacertae object ON231. The spectral energy distribution (SED) of 4C 21.35 contains a prominent infrared excess indicative of dust emission. After subtracting a non-thermal component with a power-law spectrum, we fit a dust model to the residual SED. The model consists of a blackbody with temperature ~1200 K, plus a much weaker optically thin component at ~660 K. The total luminosity of the thermal dust emission is $7.9 \pm 0.2 \times 1045$ erg s–1. If the dust lies in an equatorial torus, the density of infrared photons from the torus is sufficient to explain the γ-ray flux from 4C 21.35 as long as the scattering occurs within a few parsecs of the central engine. We also report a tentative detection of dust in the quasar CTA102, in which the luminosity of the infrared excess is $7 \pm 2 \times 1045$ erg s–1. However, in CTA102 the far-infrared spectra are too noisy to detect the 10 μm silicate feature. Upper limits to the luminosity from thermal emission from dust in PKS 1510–089, and ON231, are 2.3×1045, and 6.6×1043 erg s–1, respectively. These upper limits do not rule out the possibility of inverse Compton up-scattering of infrared photons to γ-ray energies in these two sources. The estimated covering factor of the hot dust in 4C 21.35, 22%, is similar to that of non-blazar quasars; however, 4C 21.35 is deficient in cooler dust.
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Andrea Marinucci (CfA), Guido Risaliti (CfA, INAF), Stefano Bianchi (Dipartimento di Fisica, Universita' degli Studi Roma Tre, via della Vasca Navale) , Martin Elvis (CfA), Giorgio Matt (Dipartimento di Fisica, Universita' degli Studi Roma Tre, via della Vasca Navale)

Title: X-ray Absorption Variability In NGC 4507

We present a complete spectral analysis of an XMM-Newton and Chandra campaign of the obscured AGN in NGC 4507, consisting of six observations spanning a period of six months. We detect strong absorption variability on time scales between 1.5 and 4 months, suggesting that the obscuring material consists of gas clouds at parsec-scale distance. The lack of variability on shorter time scales rules out the possibility of absorption by broad line region clouds, which was instead found in other studies of similar sources. This shows that a single, universal structure of the absorber (either BLR clouds, or the parsec-scale torus) is not enough to reproduce the observed complexity of the X-ray absorption features of AGNs.
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Alan Marscher (Boston U.)

Title: Simulating Multi-waveband Variations of Blazars: the Mother of Multi-zone Models

Multi-waveband observations of bright gamma-ray blazars (e.g., 3C 454.3) show strong optical-gamma correlations and flares that occur as superluminal knots transverse the parsec-scale core. However, the optical-gamma variations do not correspond so well when the details are examined. The author is developing a code that implements a model proposed by Marscher and Jorstad to explain this behavior. In this scenario, much of the optical and high-energy radiation in a blazar is emitted near the 43 GHz core of the jet as seen in VLBA images, parsecs from the central engine. The main physical features are a turbulent ambient jet plasma that passes through a standing recollimation shock in the jet. The model allows for short time-scales of optical and gamma-ray variability by restricting the highest-energy electrons radiating at these frequencies to a small fraction of the turbulent cells, perhaps those with a particular orientation of the magnetic field relative to the shock front. Because of this, the volume filling factor at high frequencies is relatively low, while that of the electrons radiating below about 10 THz is near unity. Such a model is consistent with the (1) red-noise power spectra of flux variations, (2) shorter time-scales of variability at higher frequencies, (3) frequency dependence of polarization and its variability, and (4) breaks in the synchrotron spectrum by more than the radiative loss value of 0.5. The numerical code simulates light curves that currently include synchrotron radiation as well as inverse Compton scattering of seed photons from both a dust torus and a Mach disk at the jet axis. The latter source of seed photons produces more pronounced variability in gamma-ray than in optical light curves, as is often observed.
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Herman L. Marshall (MIT), et al.

Title: The Jet in Pictor A: X-ray Variability and HST Observations

A Chandra X-ray imaging observation of the jet in Pictor A showed a feature that appears to be a flare that faded between 2000 and 2002. The feature was not detected in a follow-up observation in 2009. The jet itself is over 150 kpc long and a kpc wide, so finding year-long variability is surprising. Assuming a synchrotron origin of the observed high-energy photons and a minimum energy condition for the outflow, the synchrotron loss time of the X-ray emitting electrons is of order 1200 yr, which is much longer than the observed variability timescale. This leads to the possibility that the variable X-ray emission arises from a very small sub-volume of the jet, characterized by magnetic field that is substantially larger than the average over the jet.

Follow-up HST observations show that the brightest feature of the jet has a steeply dropping optical spectrum, indicating that the synchrotron cutoff is in the near IR. With strong X-ray emission that is displaced upstream of the optical and radio emission, modeling is a challenge.
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Daria Morozova, Ivan Troitskiy , Larionov, V. M.; Hagen-Thorn, V. A. (St Petersburg U.), Jorstad, S. G.; Marscher, A. P (Boston U.) **[Poster]**

Title: Multi-wavelength Study of Gamma-Ray Bright Blazars

We investigate total intensity radio images of 6 gamma-ray bright blazars (BL Lac, 3C 279, 3C 273, W Com, PKS 1510-089, and 3C 66A) and their optical and gamma-ray light curves to study connections between gamma-ray and optical brightness variations and changes in the parsec-scale radio structure. We use high-resolution maps obtained by the BU group at 43 GHz with the VLBA, optical light curves constructed by the St.Petersburg State U. (Russia) team using measurements with the 0.4 m telescope of St.Petersburg State U. (LX200) and the 0.7 m telescope of the Crimean Astrophysical Observatory (AZT-8), and gamma-ray light curves, which we have constructed with data provided by the Fermi Large Area Telescope. Over the period from August 2008 to November 2009, superluminal motion is found in all 6 objects with apparent speed ranging from 2c to 40c. The blazars with faster apparent speeds, 3C 273, 3C 279, PKS 1510-089, and 3C 66A, exhibit stronger variability of the gamma-ray emission. There is a tendency for sources with sharply peaked gamma-ray flares to have faster jet speed than sources with gamma-ray light curves with no sharp peaks. Gamma-ray light curves with sharply peaked gamma-ray flares possess a stronger gamma-ray/optical correlations.

The research at St.Petersburg State U. was funded by the Minister of Education and Science of the Russian Federation (state contract N=P123).
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Emanuele Nardini (CfA)

TITLE: X-ray absorption variability in NGC 4395

We present a new X-ray analysis of the dwarf Seyfert galaxy NGC 4395, based on two archival XMM-Newton and Suzaku observations. NGC 4395 is well known for a series of remarkable properties, such as the small mass of its central black hole, the intense flux variability on very short time-scales and an unusually flat X-ray continuum. The X-ray source is also characterized by significant variations of the spectral shape, which can be explained through the partial occultation by circumnuclear cold absorbers with column densities of 10^22–10^23 cm^-2. In this scenario, the primary X-ray emission is best reproduced by means of a power law with a standard (~2) photon index, consistent with both the spectral slope observed at higher energies and the values typically found in local AGN.
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Alessandro Paggi (CfA) [Poster]

TITLE: CHEERS: first results from deep Chandra imaging of Mrk573

We present preliminary results on Mrk573 obtained as part of the CHandra survey of Extended Emission-line Regions in nearby Seyfert galaxies (CHEERS). This source features biconical emission in the soft X-ray range, which is closely related with the Narrow Line Region as mapped by the [OIII]

emission line. We investigated the properties of soft X-ray emission from this source with new deep observations (~110 ks), finding extended emission up to 6 kpc from the nucleus. A significant emission is also detected in the direction perpendicular to the ionizing cones. Making use of the sub-pixel binning approach on the Chandra ACIS image, we resolved substructures in each ionizing cone: the two cones spectra were fitted with photo-ionization model, showing an higher ionization parameter in the southeast cone with respect to the northwest one, while a thermal collisional gas at about 1 keV appears to be located near the knot features resolved in radio observations. The nuclear region features higher ionization parameter without presence of thermal gas, and does not show significant variability, either in terms of flux or of intrinsic absorption.
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Jonathan Richardson (Yale) [Poster]

Title: The Halo Occupation Distribution of SDSS Quasars

We investigate the halo occupation distribution (HOD) of low redshift quasars, identified in the Sloan Digital Sky Survey, by analyzing the projected two-point correlation function of these objects (Ross et al. 2009). Using a HOD parametrization motivated by a cosmological hydrodynamic simulation that incorporates black hole growth and feedback (Chatterjee et al. 2011), we decompose the mean occupation of quasars into a central and a satellite component. We find a tight constraint for the median mass scale of halos hosting central quasars, log (M/M_sun) = 12.64±0.10. We also show that the quasar duty cycle (fraction of halos hosting quasars) is close to 1% at a mass scale of log (M/M_sun) = 13.75. The data is consistent with a satellite fraction of zero.
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David Roberts, John Wardle, and Valerie Marchenko (Brandeis U.)

Title: Radio Evidence for Highly Relativistic Flows in the Kiloparsec-Scale Jet of the Quasar 3C345

We present very high dynamic range VLA imaging of 3C\,345 at 5 and 8 GHz revealing a very unusual "twisted" magnetic field morphology in the jet. In a cylindrically-symmetric transparent jet a helical magnetic field would appear either transverse or longitudinal due to partial cancellations of Stokes parameters. We have made radiative transfer calculations that show that differential Doppler boosting in this very-slightly diverging jet can cause a helical magnetic field to appear twisted despite the symmetry of the jet. Constraints are derived on the magnetic field morphology and fluid speed that suggest that \beta \geq 0.95, compatible with the speeds inferred from the inverse Compton model for the X-ray jets seen by CHANDRA.
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Brook Simmons (Yale)

Title: Investigating the Slow-Growth AGN Phase at z ~ 1

Using a new method for calculating bolometric luminosities, we examine the Eddington ratios of a sample of 87 X-ray-selected obscured AGN in the GOODS fields. We find that the black holes in the sample span three orders of magnitude in mass, from 4e6 to 6e9 solar masses (median value 6e8), where the masses are estimated using bulge luminosities of the host galaxies. The majority of these AGN have Eddington ratios below 1%, and we detect no evolution in the mean Eddington ratio out to

z=1.25. This implies that the bulk of black hole growth in these obscured AGN must have occurred at z>1 and that we are observing them in a slow- or no-growth state. Our bolometric luminosities, based on dust-corrected central point-source SEDs, have a smaller spread than do alternative estimates from corrections to the X-ray luminosity or direct SED integration, suggesting our new method yields a better measure of bolometric luminosity; these values also agree with theoretical models of AGN luminosity based on a unification scenario.
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Charles Steinhardt (IPMU)

Title: Broad OIII Emission in SDSS Quasars

I will describe a previously unreported class of Type I quasars with O{\small III} broader than 1200 km/s, above the velocity believed possible for gas in the quasar narrow-line region. These "broad O{\small III} quasars" (BOQ) comprise approximately one quarter of the Type I quasar population at $0.2 < z < 0.8$. Further, broadened O{\small III} is tightly correlated with changes in other spectral lines such as the Hβ broad component as well as the ratio of optical to radio and x-ray flux, so that the set of BOQs comprises a unique population. Broadened O{\small III} is also correlated with a decrease in O{\small II} an indicator of star formation in the host galaxy, with O{\small II} disappearing entirely for the quasars with the broadest narrow lines. BOQs may also be associated with a breakdown in virial mass estimators using the Hβ line. A determination of the cause of this correlation might provide direct evidence of a connection between the host galaxy and its central quasar at these redshift. However, several models for BOQs are considered and can be rejected based upon properties of the observed quasars and their spectra.
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Junfeng Wang (CfA)

Title: Chandra Views it All: a Photoionized Bi-conical Outflow, a Frustrated Radio Jet, and a Leaky Torus in NGC 4151

We present new results from deep Chandra imaging of NGC 4151, focusing on the X-ray morphology of NGC 4151 on spatial scales of ~30 pc to ~3 kpc. In combination with high resolution multi-wavelength images (HI, CO, [OIII], Halpha, [FeII] and H2), we are obtaining a full view of the multiphase ISM in the nuclear region of NGC 4151, tracing both AGN feeding and its feedback. I will discuss new evidence for interaction between the radio jet and the NLR clouds, a photoionized outflow, and the detection of X-ray emission from faint clouds ionized by nuclear radiation through a leaky torus.
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John Wardle, E. A. Dare (Brandeis U.), C. C. Cheung (NRL)

Title: On the Nature of the Microquasar GRS 1915+105: Clues from Radio Polarization Imaging.

We present a sequence of images of the polarized radio emission from the Galactic superluminal source GRS 1915+105 made from archival VLA data taken in 1994. Between February and April there are 10 observations made in the A array, mostly at 8 GHz, and four outbursts can be seen. The images reveal a wealth of information which cannot be obtained from the total intensity images. The second and third outbursts are well observed in polarization and they exhibit very different behaviors. In the second

outburst the magnetic field direction is aligned along the jets throughout the burst. We show that the evolution of the total intensity and fractional polarization can be fit with a simple shock-in-jet model. The third outburst (in which Mirabel and Rodriguez discovered superluminal motion) behaves quite differently. It is a much more powerful outburst and it decays more slowly than the second outburst. Its polarization behavior is complex. The polarization electric vector position angles in both jets rotate rapidly, but in opposite directions. The fractional polarization also changes in a complex way indicating internal polarization structure. In the last three epochs the VLA resolves this polarization structure in the south-east jet. The third outburst evolves too rapidly and in too complex a manner to fit a detailed model, but a qualitative description in terms of the shock-in-jet model can be given.
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