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Abstracts - Thesis Abstracts - Jobs - Meetings

From the Editor

The Active Galaxies Newsletter is produced monthly. The deadline for contributions is the last friday of the month. The Latex macros for submitting abstracts and dissertation abstracts are appended to each issue of the newsletter and are also available on the web page.
Matt Redman

Abstracts of recently accepted papers

Compton-thick X-ray absorption in the Seyfert galaxies Tololo 0109–383 and ESO 138–G1

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We present analyses of the *ASCA* X-ray spectra of two Seyfert galaxies, Tololo 0109–383 and ESO 138–G1. In both cases, spectral fitting reveals two statistically acceptable continuum models: Compton reflection and partial covering. Both spectra have strong iron Kα lines, with equivalent widths greater than 1.5 keV. These large equivalent widths are suggestive of heavier obscuration than that directly indicated by the partial-covering models ($\approx 2 \times 10^{23}$ cm^{-2}), with the actual column densities being 'Compton-thick' (i.e. $N_{\rm H} > 1.5 \times 10^{24}$ cm^{-2}). We use the hard X-ray/[O III] flux correlation for Seyferts and data from the literature to provide additional support for this hypothesis. Since Tololo 0109–383 is known to have optical type 1 characteristics such as broad Balmer line components and Fe II emission, this result marks it as a notable object.

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Preprint available at http://www.astro.psu.edu/users/niel/papers/papers.html

An optical and X-ray study of the peculiar narrow-line quasar QSO 0117-2837

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We present an optical and X-ray study of the quasar QSO 0117-2837. It exhibits an interesting combination of optical and X-ray properties: Despite its extremely steep observed X-ray spectrum ($\Gamma_{\rm x} \simeq -4$ when fit by a simple powerlaw), its Balmer lines are fairly broad. A two-component Gaussian fit to Hβ yields FWHM$_{{\rm H}\beta,{\rm broad}} \simeq 4000$ km/s, and places QSO 0117-2837 in the 'zone of avoidance' in the FWHM$_{{\rm H}\beta}$–$\Gamma_{\rm x}$ diagram. A time variability analysis shows that QSO 0117-2837 is another case of

Narrow-line Sy 1 galaxy (NLSy1 hereafter) which does *not* show any X-ray variability during the observation. The results are discussed in view of the NLSy1 character of QSO 0117-2837.

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Evidence for Supermassive Black Holes in Active Galactic Nuclei from Emission-Line Reverberation

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Emission-line variability data for Seyfert 1 galaxies provide strong evidence for the existence of supermassive black holes in the nuclei of these galaxies, and that the line-emitting gas is moving in the gravitational potential of that black hole. The time-delayed response of the emission lines to continuum variations is used to infer the size of the line-emitting region, which is then combined with measurements of the Doppler widths of the variable line components to estimate a virial mass. In the case of the best-studied galaxy, NGC 5548, various emission lines spanning an order of magnitude in distance from the central source show the expected $V \propto r^{-1/2}$ correlation between distance and line width, and are thus consistent with a single value for the mass. Two other Seyfert galaxies, NGC 7469 and 3C 390.3, show a similar relationship. We compute the ratio of luminosity to mass for these three objects and the narrow-line Seyfert 1 galaxy NGC 4051 and find that that the gravitational force on the line-emitting gas is much stronger than radiation pressure. These results strongly support the paradigm of gravitationally bound broad emission-line region clouds.

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preprint available at http://xxx.lanl.gov/abs/astro-ph/0007147

Four Years of Extreme Ultraviolet Observations of Markarian 421. I: Spectral Analysis

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We analyzed the ~ 950 ks of spectroscopic data accumulated by the *Extreme Ultraviolet Explorer* (*EUVE*) satellite between 1994 and 1997 for the BL Lacertae object Markarian 421. The EUV spectrum is well detected in the 70–110 Å (112–177 eV) range and can be fitted by a power law model plus the $\sim 71 - 75$ Å range. Previous studies of EUV absorption features in MRK 421 and in the other EUV bright BL Lac object, PKS2155−304, explain this absorption feature as a superposition of Doppler-smeared absorption lines (mainly L- and M-shell transitions of Mg and Ne) originating in high-velocity gas clouds ionized by the beamed continuum of the associated relativistic jet. We show that, for example, Fe IX L could also be a possibility consistent with the marginal detection of oxygen absorption lines in the X-ray range. However physical models are highly sensitive to the assumptions on the photoionizing continuum and the surrounding gas.

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Four Years of Extreme Ultraviolet Observations of Markarian 421. II: Temporal Analysis

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The *Extreme Ultraviolet Explorer* (*EUVE*) satellite accumulated $\sim$ one million seconds of public data between 1994 and 1997 for the BL Lacertae object Markarian 421. This is the second of two papers in which we present the results of spectral and temporal analysis of this *EUVE* data set. We analyze in the present paper the imaging data by means of power spectrum and structure function techniques, while the spectral analysis is presented in a companion paper. We find for MRK 421 a power spectrum with slope -2.14 ± 0.28 with a break at ~ 3 days. This is the first time that a break in the power spectrum of a BL Lacertae object has been found. We also find evidence of non-stationarity for MRK 421 EUV emission.

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The Young Starburst Nucleus of the Wolf-Rayet LINER Galaxy NGC 6764

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Near-infrared K band imaging spectroscopy of the central 8" (1.3 kpc) in the Wolf-Rayet LINER galaxy NGC 6764 shows that the most recent star formation is most likely still unresolved at sub-arcsecond resolution (< 100 pc). The K band continuum source has a size of about 1.5" (240 pc). In addition to stellar CO and Na absorption lines as well as recombination lines of H and He, the K band spectrum shows several strong emission lines from molecular hydrogen (H_2). The H_2 line emission is spatially and spectrally resolved showing a rotating ring/disk of ~ 1.2" (200 pc) diameter.
An analysis of the nuclear (3" $\sim$ 480 pc) stellar light using population synthesis models in conjunction with NIR spectral synthesis models suggests following star formation history: Two starbursts with decay times of 3 Myr occurred 3 to 5 Myr and 15 to about 50 Myr ago. Continuous star formation with a SFR of ~ 0.3 $M_\odot$ yr^{-1} over at least 1 Gyr can also explain the observed parameter. However, the mass relocation and consumption involved as well as the different spatial distribution of the lines associated with the star formation strongly favor the 'two starburst' scenario. In that scenario, up to 35% of the total observed Brγ flux could still be due to the AGN, depending on the assumed age of the older starburst event. In contrast to other starburst galaxies (e.g. M82, NGC 7552), the younger starburst in NGC 6764 is very likely located closer to the nucleus and surrounded by the older starburst. One possible explanation can be that the stellar bar still transports gas down to radii close to the nucleus. This suggests that the massive star formation activity is directly competing with the AGN for the fuel.
We also present the results of a 44 ksec. HRI ROSAT exposure. The HRI data show the presence of a X-ray source (probably an AGN) which varies by more than a factor of 2 over a time scale of 7 days. This implies the presence of a compact source with a discrete or at most 1000 AU source size. In addition, we find an extended X-ray component which looks similar to the radio continuum emission presented in published VLA maps. Both data sets confirm the composite nature of the center of NGC 6764: the presence of a compact AGN as well as recent violent nuclear star formation.

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The X-ray absorber in broad absorption line Quasars

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Recent observations of Broad Absorption Line (BAL) quasars demonstrated that the soft X-ray emission of these objects is extremely weak and convincing evidence for very strong absorption by a high column density ($\sim 10^{23.5}$ cm^{-2}) was obtained for PG 1411+442, even though it is one of the few BAL QSOs strongly detected in soft X-rays. This paper examines the ionization status and geometry of the X-ray absorber by combining the properties of the UV lines with the X-ray continuum absorption. We show that the gas has to have large column densities in ions of major UV absorption lines, such as CIV, NV, OVIand Ne VIII, in order to have sufficient opacity around 0.2 to 0.35 keV. The UV absorption lines have to be saturated if the X-ray absorber intersects the line of sight to the UV continuum emission region. A uniformly covering UV and X-ray absorption model can be constructed for PG 1411+442 but in some other soft X-ray detected BAL QSOs, such as PG 1001+054, the observed line optical depth is much lower than expected from the X-ray absorbing material. We propose a scheme in which a substantialfraction of the line of sight to the continuum source may be covered by either an optically thick flow or clouds in a

narrow velocity range, but in which thetotal covering factor of either the whole flow or all clouds is close to unity.

The absorber can contribute significantly to the extremely highly ionized emission lines, such as O VI 1032/1037Å and Ne VIII 770/780Å if it covers a substantial fraction of solid angle and if the density is higher than 10^8 cm^{-3}. However, it has very little impact on the medium and low ionization UV lines such as NV, CIV. The profiles of NeVIII and OVI lines may be indicators for the kinematics of the X-ray absorber in QSOs. The observed Ne VIII line profiles in QSOs suggests that the velocity of the gas projected onto our line of sight is similar to that seen in the outflows of the UV BALs.

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A Structure for Quasars

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This paper proposes a simple, empirically derived, unifying structure for the inner regions of quasars. This structure is constructed to explain the broad absorption line (BAL) regions, the narrow 'associated' ultraviolet and X-ray 'ionized' absorbers (NALs); and is also found to explain the broad emission line regions (BELR), and several scattering features, including a substantial fraction of the broad X-ray Iron-K emission line, and the bi-conical extended narrow emission line region (ENLR) structures seen on large kiloparsec scales in Seyfert images.

The model proposes that a funnel-shaped thin shell outflow creates all of these features. The wind arises vertically from a narrow range of radii on a disk at BELR velocities. Radiation force then accelerates the flow radially, so that it bends outward to a cone angle of ~60°, and has an divergence angle of ~6°, to give a covering factor of ~10%. When the central continuum is viewed from the side, through this wind, narrow high ionization 'associated' ultraviolet absorption lines and the X-ray 'ionized absorbers' are seen, as in many low luminosity active galactic nuclei. When viewed end-on the full range of velocities is seen in absorption with a large total column density, giving rise to the broad absorption lines systems seen in a minority of quasars, the BALQSOs.

The wind is both warm ($\sim 10^6$ K) and highly ionized. This warm highly ionized medium (WHIM) has a density of $\sim 10^9$ cm^{-3}, putting it in pressure equilibrium with the BELR clouds; the BELR is then a cool phase embedded in the overall outflow, avoiding cloud destruction through shear. The wind has the correct ionization parameter and filling factor for this. The high and low ionization zones of the BELR correspond to the cylindrical and conical regions of the wind, since the former is exposed to the full continuum, while the latter receives only the continuum filtered by the former.

The warm wind is significantly Thomson thick along the radial flow direction, producing the polarized optical continuum found in BALs, but is only partially ionized, creating a broad fluorescent 6.4 keV Fe-K emission line, and >10 keV Compton hump. The conical shell outflow can produce a bi-conical matter bounded NELR.

Luminosity dependent changes in the structure, reducing the cylindrical part of the flow, or increasing the mean angle to the disk axis and decreasing the wind opening angle, may explain the UV and X-ray Baldwin effects and the greater prevalence of obscuration in low luminosity AGN.

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Hard X-ray Emission and the Ionizing Source in LINERs

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We report X-ray fluxes in the 2–10 keV band from LINERs (low-ionization nuclear emission-line regions) and low-luminosity Seyfert galaxies obtained with the *ASCA* satellite. Observed X-ray luminosities are in the range between 4×10^{39} and 5×10^{41} ergs s^{-1}, which are significantly smaller than that of the "classical" low-luminosity Seyfert 1 galaxy NGC 4051. We found that X-ray luminosities in 2–10 keV of LINERs with broad Hα emission in their optical spectra (LINER 1s) are proportional to their Hα luminosities. This correlation strongly supports the hypothesis that the dominant ionizing source in LINER 1s is photoionization by hard photons from low-luminosity AGNs. On the other hand, the X-ray luminosities of most LINERs without broad Hα emission (LINER 2s) in our sample are lower than LINER 1s at a given Hα luminosity. The observed X-ray

luminosities in these objects are insufficient to power their Hα luminosities, suggesting that their primary ionizing source is other than an AGN, or that an AGN, if present, is obscured even at energies above 2 keV.

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The frequency of nuclear star-formation in Seyfert 2 galaxies

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We investigate the detectability of starburst signatures in the nuclear spectrum of Seyfert 2 galaxies by constructing spectral models in the wavelength range $\lambda\lambda$3500–4100Å, combining the spectrum of a bulge population (of age ≈10 Gyr) with that of younger stellar populations, spanning ages from ≈3 Myr to 1 Gyr. The major constraints in the analysis are: (i) the continuum ratio 3660Å/4020Å, which efficiently discriminates between models combining a bulge spectrum with a stellar population younger than ≈50 Myr and those with older stellar populations; (ii) the presence of the Balmer lines H8, H9 and H10 in absorption, which are unambiguous signatures of stellar populations with ages in the range 10 Myr–1 Gyr for the relevant metallicities. Their detectability depends both on the age of the young component and on its contribution to the total flux relative to that of the bulge.

We also construct models combining the bulge template with a power-law (PL) continuum, which is observed in some Seyfert 2's in polarized light, contributing with typically 10–40% of the flux at λ4020Å. We conclude that such continuum cannot be distinguished from that of a very young stellar population (age≤10 Myr), contributing with less than ≈0.02% of the mass of the bulge.

The models are compared with nuclear spectra — corresponding to a radius of 200–300 pc at the galaxy — of 20 Seyfert 2 galaxies, in which we specifically look for the signatures above of young to intermediate age stellar populations. We find them in ten galaxies, thus 50% of the sample. But only in six cases (30% of the sample) they can be attributed to young stars (age <500 Myr): Mrk 1210, ESO 362-G8, NGC 5135, NGC 5643, NGC 7130 and NGC 7582. In the remaining four cases, the signatures are due to intermediate age stars (≈1 Gyr).

We find a tendency for the young stars to be found more frequently among the late type Seyfert's. This tendency is supported by a comparison between the equivalent widths (W) of absorption lines of the nuclear spectra of the Seyfert 2's with those of normal galaxies of the same Hubble type: for the late-type (Sb or later), the W values of the Seyfert's are within the observed range of the normal galaxies, while the W values are lower than those of the normal galaxies for 7 out of the 11 early-type galaxies (S0 and Sa).

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HST/NICMOS Observations of the Host Galaxies of Powerful Radio Sources: Does size Matter?

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We present near-infrared J and K band imaging of a sample of powerful radio source host galaxies with the Hubble Space Telescope NICMOS2 camera. These sources have been selected on their double lobed radio structure, and include a wide range of projected radio source sizes. The largest projected linear sizes range from the compact Gigahertz Peaked Spectrum (GPS, < 1 kpc) and Compact Steep Spectrum (CSS, < 20 kpc) radio sources, up to the large-scale (> 20 kpc) classical doubles (FR II radio sources). We investigate the dependence of host galaxy properties (including near-IR surface brightness profiles) on radio source size, using both our own and published data. The absolute magnitudes and surface brightness profiles are consistent with the host galaxies being regular giant elliptical galaxies rather than Brightest Cluster Galaxies (BCGs). We find that the

GPS, CSS, and FR II host galaxies are a uniform class of objects, consistent with a scenario in which a powerful radio source evolves along this size sequence.

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Thesis abstract

Are Radio-loud Quasars Rebellious or Are Radio-quiets Just Plain Untalented?

A Study of the Ultraviolet Broad Emission Line Profiles in High-redshift Radio-loud and Radio-quiet Quasars

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A UV spectroscopic study of $z \approx 1.5-3.5$ quasars was carried out using high-quality, ∼4 Å resolution ground-based spectra of ∼130 quasars of moderate brightness for their class. VLA radio data at 2 − 3 frequencies are available for the radio-loud quasars. More than 40 pairs of radio-loud and radio-quiet quasars were matched one-to-one in luminosity and redshift to within typical uncertainties in these parameters in order to limit the effects of these parameters on a comparison study of the two quasar types. The ultimate goal is to analyze in detail their restframe UV spectra for clues to their fundamental differences and to identify potential radio-independent inclination indicators, applicable to radio-quiet quasars. The adopted approach includes (1) a careful object selection for a statistical comparison of the UV spectra in the radio-loud and radio-quiet quasar samples, (2) use of a robust parameter scheme, including the interpercentile parameters presented by Whittle (1985, MNRAS, 213, 1), and (3) a reliable error estimation. Detailed modeling of the line profiles (similar to Laor et al. 1994, ApJ, 420, 110) is performed to reduce errors on the measured parameters due to varying signal-to-noise among the spectra and to absorption lines superposed on the emission lines. In this work the focus is placed on the detailed analysis of the C IV λ1549 line profile and selected results are presented below; future work will present the analysis of the remaining emission lines. Radio-loud quasars are found to have relatively peakier lines, stronger and narrower line cores, and predominantly red asymmetries, while radio-quiet quasars have blue asymmetries on average. The ∼25% peak line width correlates strongly with aspect angle in this sample of radio-loud quasars, while the FWHM and the narrow line core width do not. This indicates that the lowest velocity gas is emitted isotropically from gas with an inclination independent velocity field, in contrast to the line base. A comparison of the C IV and Hβ profile properties and behavior is undertaken, using results from earlier reported studies of the Hβ line profile in low-z sources. Similar aspect angle dependencies are found for the C IV and Hβ profiles. It is argued that the high-velocity C IV emitting line region is a flattened configuration close to the Balmer line emitting accretion disk (Vestergaard 1999a, BAAS, 193, #27.02; Vestergaard, Wilkes, & Barthel 2000, ApJL, 538, 103).

Based on the results of the discussion and the assumption that the results can be extrapolated to the entire radio-loud and radio-quiet quasar populations, a model scenario is proposed to explain the observed differences in the properties of the two quasar types (Vestergaard 1999b, BAAS, 194, #20.06). It is suggested that the distribution and possibly the amount of dust differs among quasars depending on their radio power, such that radio-quiet quasars are relatively more affected by dust. A

kinematic scenario is suggested to explain the generation of powerful radio jets in a small fraction of quasars based on the black hole spin rate, the disk rotation rate, and the magnetic field strength. Further work is needed to confirm the results and to test the proposed quasar model scenario both observationally and theoretically.

An empirical iron emission template is generated (Vestergaard & Wilkes 2000, ApJ, submitted) to allow a modeling and subtraction of iron emission lines which often contaminate the wings of the prominent UV broad emission lines and complicate their study. An application of the template to the spectral database of this study will be presented in forthcoming work.

A more detailed abstract is submitted to PASP.

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