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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.
Rob Beswick

Abstracts of recently accepted papers

High-Resolution X-ray Spectroscopy and Modeling of the Absorbing and Emitting Outflow in NGC 3783

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The high-resolution X-ray spectrum of NGC 3783 shows several dozen absorption lines and a few emission lines from the H-like and He-like ions of O, Ne, Mg, Si, and S as well as from Fe XVII–Fe XXIII L-shell transitions. We have reanalyzed the *Chandra* HETGS spectrum using better flux and wavelength calibrations along with more robust methods. Combining several lines from each element, we clearly demonstrate the existence of the absorption lines and determine they are blueshifted relative to the systemic velocity by -610 ± 130 km s^{-1}. We find the Ne absorption lines in the High Energy Grating spectrum to be resolved with FWHM = 840^{+490}_{-360} km s^{-1}; no other lines are resolved. The emission lines are consistent with being at the systemic velocity. We have used regions in the spectrum where no lines are expected to determine the X-ray continuum, and we model the absorption and emission lines using photoionized-plasma calculations. The model consists of two absorption components, with different covering factors, which have an order of magnitude difference in their ionization parameters. The two components are spherically outflowing from the AGN and thus contribute to both the absorption and the emission via P Cygni profiles. The model also clearly requires O VII and O VIII absorption edges. The low-ionization component of our model can plausibly produce UV absorption lines with equivalent widths consistent with those observed from NGC 3783. However, we note that this result is highly sensitive to the unobservable UV-to-X-ray continuum, and the available UV and X-ray observations cannot firmly establish the relationship between the UV and X-ray absorbers. We find good agreement between the *Chandra* spectrum and simultaneous *ASCA* and *RXTE* observations. The 1 keV deficit previously found when modeling *ASCA* data probably arises

from iron L-shell absorption lines not included in previous models. We also set an upper limit on the FWHM of the narrow Fe Kα emission line of 3250 km s^{-1}. This is consistent with this line originating outside the broad line region, possibly from a torus.

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preprint available at http://arXiv.org/abs/astro-ph/0101540

In the Shadow of the Accrection Disk: Higher Resolution Imaging of the Central Parsec in NGC 4261

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The physical conditions in the inner parsec of accretion disks believed to orbit the central black holes in active galactic nuclei can be probed by imaging the absorption (by ionized gas in the disk) of background emission from a radio counterjet. We report high angular resolution VLBI observations of the nearby (~ 40 Mpc) radio galaxy NGC 4261 that confirm free-free absorption of radio emission from a counterjet by a geometrically thin, nearly edge-on disk at 1.6, 4.8, and 8.4 GHz. The angular width and depth of the absorption appears to increase with decreasing frequency, as expected. We derive an average electron density of $\sim 10^4$ cm^{-3} at a disk radius of about 0.2 pc, assuming that the inner disk inclination and opening angles are the same as at larger radii. Pressure balance between the thermal gas and the magnetic field in the disk implies an average field strength of 10^{-4} gauss at a radius of 0.2 pc. These are the closest-in free-free absorption measurements to date of the conditions in an extragalactic accretion disk orbiting a black hole with a well-determined mass. If a standard advection-dominated accretion flow exists in the disk center, then the transition between thin and thick disk regions must occur at a radius less than 0.2 pc (4000 Schwarzschild radii).

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A Chandra Study of Sgr A East: A Supernova Remnant Regulating The Activity of Our Galactic Center?

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We report on the X-ray emission from the shell-like, non-thermal radio source Sgr A East (SNR 000.0+00.0) located in the inner few parsecs of the Galaxy based on observations made with the ACIS detector on board the *Chandra X-ray Observatory*. This is the first time Sgr A East has been clearly resolved from other complex structures in the region. The X-ray emitting region is concentrated within the central $\simeq 2$ pc of the larger radio shell. The spectrum shows strong Kα lines from highly ionized ions of S, Ar, Ca, and Fe. A simple isothermal plasma model gives electron temperature ~ 2 keV, absorption column $\sim 1 \times 10^{23}$ H cm^{-2}, luminosity $\sim 8 \times 10^{34}$ ergs s^{-1} in the 2–10 keV band, and gas mass $\sim 2\eta^{\frac{1}{2}}$ M$_\odot$ with a filling factor η. The plasma appears to be rich in heavy elements, over-abundant by roughly a factor of four with respect to solar abundances, and shows a spatial gradient of elemental abundance: the spatial distribution of iron is more compact than that of the lighter elements.

The gas mass and elemental abundance of the X-ray emission support the long-standing hypothesis that Sgr A East is a supernova remnant (SNR), maybe produced by the Type II supernova explosion of a massive star with a main-sequence mass of 13–20 M$_\odot$. The combination of the radio and X-ray morphologies classifies Sgr A East as a new metal-rich "mixed morphology" (MM) SNR. The size of the Sgr A East radio shell is the smallest of the known MM SNRs, which strongly suggests that the ejecta have expanded into a very dense interstellar medium. The ejecta-dominated chemical compositions of the plasma indicate that the ambient materials should be highly homogeneous.

We thus evaluate a simplified dynamical evolution model where a SNR was formed about 10,000 years ago and expanded into an ambient medium with a homogeneous density of 10^3 cm^{-3}. The model roughly reproduces most of the observed properties in

the X-ray and radio wavelengths. A comparison with the radio observations requires the dense ambient medium to be ionized, but a luminous X-ray irradiator with an expected X-ray luminosity of $\sim 10^{40}$ ergs s^{-1} is not currently present. The presence of the ionized gas may be explained if the massive black hole (MBH) associated with the compact, non-thermal radio source Sgr A* was bright in X-rays about three hundred years ago, but is presently dim. It is possible that the dust/molecular ridge compressed by the forward shock of Sgr A East hit Sgr A* in the past, and the passage of the ridge may have supplied material to accrete onto the black hole in the past, and may have removed material from the black hole vicinity, leading to its present quiescent state. This may be a specific example of the intimate relationship between a SNR and massive black hole accretion activity in galactic nuclei.

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preprint available at astroph (http://xxx.lanl.gov/find/astro-ph).
press release article regarding this study available at http://chandra.harvard.edu/press/01_releases/press_020101.html

Do LINER 2 galaxies harbour low-luminosity Active Galactic Nuclei?

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We use *ROSAT* HRI spatial data and *ASCA* spectral measurements for a sample of seven nearby, early type spiral galaxies, to address the question of whether a low-luminosity Active Galactic Nucleus (LLAGN) is present in galaxies that have a LINER 2 classification. The brightest discrete X-ray source in the *ROSAT* HRI observations is invariably found to be positionally coincident with the optical galactic nucleus, and in most cases its flux dominates the X-ray emission from the central region of the galaxy. All seven galaxies have X-ray spectra consistent with a two-component, soft thermal plus hard power-law, spectral form. If we exclude the two galaxies with relatively hard X-ray spectra, NGC 3628 and NGC 4594, for which there is supporting evidence for a LLAGN (or alternatively in the case of NGC 3628 a dominant ultra-luminous X-ray binary), then the remaining galaxies show surprisingly similar X-ray spectral properties. Specifically the flux ratio $F_X(0.5\text{-}1)/F_X(2\text{-}5)$, which measures the relative strengths of the thermal and non-thermal emission components, shows little scatter about a mean of 0.66, a value very similar to that measured in the classic starburst galaxy NGC 253. Since there is no obvious reason why the luminosity of the hard power-law continuum emanating from a putative LLAGN should be very closely correlated with the thermal emission of the surrounding region, this suggests that that the broad-band (0.5-5 keV) X-ray emission from these LINER 2 galaxies may originate in a common set of processes probably associated with the starburst phenomenon. Conversely, it appears that in many, perhaps the majority, of LINER 2 galaxies, the nuclear X-ray luminosity does not derive directly from the presence of a LLAGN.

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Monitoring of the optical and 2.5 – 11.7 μm spectrum and mid-IR imaging of the Seyfert 1 galaxy Mrk 279 with ISO

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Mid-infrared images of the Seyfert 1 galaxy Mrk 279 obtained with the ISO satellite are presented together with the results of a one-year monitoring campaign of the 2.5–11.7 μm spectrum. Contemporaneous optical photometric and spectrophotometric observations are also presented. The galaxy appears as a point-like source at the resolution of the ISOCAM instrument (4–5 ″). The 2.5–11.7 μm average spectrum of the nucleus in Mrk 279 shows a strong power law continuum with $\alpha = -0.80 \pm 0.05$ ($F_\nu \propto \nu^\alpha$) and weak PAH emission features. The Mrk 279 spectral energy distribution shows a mid-IR bump, which extends from 2 to 15–20 μm. The mid-IR bump is consistent with thermal emission from dust grains at a distance of ≥ 100 lt-d. No significant variations of the mid-IR flux have been detected during our observing campaign, consistent with the relatively low amplitude (~ 10 % rms) of the optical variability during the campaign. The time delay for Hβ line emission in response to the optical continuum variations is $\tau = 16.7^{+5.3}_{-5.6}$ days, consistent with previous measurements.

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Absorption and Reddening in the Seyfert Galaxy NGC 3227[1]

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We have obtained low-dispersion spectra of NGC 3227 with the Space Telescope Imaging Spectrograph (STIS) to study the intrinsic UV absorption and the reddening of the nucleus in this Seyfert 1 galaxy. The UV spectra show a wealth of absorption lines at the systemic redshift that span a wide range in ionization state (Mg I to N V). The equivalent widths of the lines are consistent with our earlier prediction that a "lukewarm absorber" (T_e = 18,000 K at the ionized face) with a substantial column of gas (N_H = 2 x 10^{21} cm^{-2}) is present and likely responsible for the reddening of the nucleus. The lukewarm absorber is also responsible for most of the absorption in the X-rays at energies less than 1 keV, although a more highly ionized "warm absorber" is needed to account for the O VII and O VIII ionization edges. In addition, we require a small column (N_H = 5 x 10^{19} cm^{-2}) of cold gas to match the strengths of the neutral and singly-ionized lines in the UV spectra. NGC 3227 is the first Seyfert galaxy in which a strong link between the reddening and intrinsic UV absorption has been found. By comparing our STIS UV and optical spectra with those of the unreddened Seyfert NGC 4151, we have determined a reddening curve for the nuclear continuum source in NGC 3227 over the 1150 – 10,200 Å range. The reddening curve does not show a 2200 Å bump, and is steeper in the UV than reddening curves derived for the Galaxy, LMC, and SMC, suggesting a preponderence of small dust grains near the nucleus.

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A Survey for Large Separation Lensed FIRST Quasars

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Little is known about the statistics of gravitationally lensed quasars at large ($7'' - 30''$) image separations, which probe masses on the scale of galaxy clusters. We have carried out a survey for gravitationally-lensed objects, among sources in the FIRST 20cm radio survey that have unresolved optical counterparts in the digitizations of the Palomar Observatory Sky Survey. From the statistics of ongoing surveys that search for quasars among FIRST sources, we estimate that there are about 9100 quasars in this source sample, making this one of the largest lensing surveys to date. Using broad-band imaging, we have isolated all objects with double radio components separated by $5'' - 30''$, that have unresolved optical counterparts with similar BVI colours. Our criteria for similar colours conservatively allow for observational error and for colour variations due to time delays between lensed images. Spectroscopy of these candidates shows that none of the pairs are lensed quasars. This sets an upper limit (95% confidence) on the lensing fraction in this survey of 3.3×10^{-4}, assuming 9100 quasars. Although the source redshift distribution is poorly known, a rough calculation of the expected lensing frequency and the detection efficiencies and biases suggests that simple theoretical expectations are of the same order of magnitude as our observational upper limit. Our procedure is novel in that our exhaustive search for lensed objects does not require prior identification of the quasars in the sample as such. Characterization of the FIRST-selected quasar population will enable using our result to constrain quantitatively the mass properties of clusters.

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The BeppoSAX High Energy Large Area Survey. IV. On the soft X–ray properties of the hard X–ray-selected HELLAS sources

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We present a comprehensive study of the soft X–ray properties of the BeppoSAX High-Energy Large Area Survey (HELLAS) sources. A large fraction (about 2/3) of the hard X–ray selected sources is detected by ROSAT. The soft X–ray colors for many of these objects, along with the 0.5–2 keV flux upper limits for those undetected in the ROSAT band, do imply the presence of absorption. The comparison with the ROSAT Deep Survey sources indicates that a larger fraction of absorbed objects among the HELLAS sources is present, in agreement with their hard X–ray selection and the predictions of the X–ray background synthesis models. Another striking result is the presence of a soft (additional) X–ray component in a significant fraction of absorbed objects.

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Complex Variability Pattern in NGC 4151. III. Variability of the Broad Emission-Line Profiles over 11 Years

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We present results of an optical spectral monitoring campaign of the Seyfert galaxy NGC 4151 carried out with a CCD spectrograph at the 2.6 m Shajn Telescope of the Crimean Astrophysical Observatory in 1988–1998. 423 spectra of NGC 4151 were obtained in the H_α and H_β spectral regions. After a very deep minimum in 1984–1989, the nucleus brightened gradually, reached its brightest recorded level in 1996, and then decreased gradually. The broad emission-line profiles have shown strong changes in flux as well as in shape. The central red part of the Balmer lines strengthened systematically with respect to the total line flux, while the wings at $\pm(2500\text{–}5000)\,km\,s^{-1}$ decreased. The He II λ4686 integrated flux and its profile shape show a significantly different variation to the Balmer lines. Root mean square (rms) profiles show that the strongest absolute changes in the Balmer lines occurred near the line center. Also, there are three local maxima at -3900, -1400, and $+4300\,km\,s^{-1}$. The velocity dependence of the line–continuum correlation and correlation matrices show that two regions of poor correlation (up to an anti-correlation), sometimes remarkably narrow, occurred, on average, at -4200 and $+5000\,km\,s^{-1}$. The line–continuum correlation for the total H_α flux since 1992 is much better than the correlation for the most of the individual profile segments. The observed evolution of the Balmer line profiles can be reasonably reproduced by a two-component model in which the changes in the profile shapes are due to changes in the relative strength of the two variable components with fixed profile shapes: double-peaked and single-peaked. We suppose that the ionizing continuum produced by the central engine is then redistributed between the two components. A double-peaked component may be emitted from the Keplerian disk ionized by scattered and reprocessed radiation, while a single-peaked component may be attributed to the gas system ionized by primary radiation. As to the total line fluxes, we suppose that the observed changes in the line–continuum correlation are driven by the changes in the spectral energy distribution (SED). Our results are also relevant to the problem of the 2-dimensional reverberation mapping.

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light curves are available at http://www.crao.crimea.ua/~sergeev/papers.php3

Detection of Nuclear X-ray Sources in Nearby Galaxies with *Chandra*

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We report preliminary results from an arcsecond-resolution X-ray survey of nearby galaxies using the Advanced CCD Imaging Spectrometer (ACIS) on board the *Chandra X-ray Observatory.* The total sample consists of 41 low-luminosity AGNs, including Seyferts, LINERs, and LINER/H II transition objects. In the initial subsample of 24 objects observed thus far, we detect in ~62% of the objects a compact, point-like source astrometrically coincident with either the optical or radio position of the nucleus. The high detection rate strongly suggests that the majority of the objects do contain weakly active, AGN-like cores, presumably powered by central massive black holes. The 2–10 keV luminosities of the nuclear sources range from $< 10^{38}$ to 10^{41} erg s^{-1}, with a median value of 2×10^{38} erg s^{-1}. Our detection limit corresponds to $L_{\rm X}$(2–10 keV) $\approx 8\times10^{37}$ erg s^{-1} for the typical sample distance of 12 Mpc; this limit is two orders of magnitude fainter than the weakest sources of this kind previously studied using *ASCA* or *BeppoSAX*. The new data extend toward lower luminosities the known linear correlation between hard X-ray and Hα luminosity for broad-line AGNs. Many narrow-line objects do contain X-ray cores, consistent with either weak AGNs or X-ray binary systems, but they have X-ray luminosities a factor of 10 below the $L_{\rm X}$–$L_{\rm H\alpha}$ relation of the broad-line sources. Their distributions of photon energies show no indication of exceptionally high absorption. The optical line emission in these nuclei is likely powered, at least in part, by stellar processes.

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Nuclear Luminosities and Radio Loudness of Seyfert Nuclei

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Historically, Seyfert nuclei have been considered to be radio-quiet active galactic nuclei (AGNs). We question this widely held assumption by showing that the distribution of the radio-to-optical luminosity ratio, $R \equiv L_\nu(6\ {\rm cm})/L_\nu(B)$, when properly measured for the *nuclear* component, places the majority of type 1 Seyfert nuclei in the category of radio-loud AGNs, defined here as objects with $R \geq 10$. This result is further strengthened by strong correlations found between radio power and optical continuum and emission-line luminosities, as has been established previously for more powerful AGNs. We also present a new calibration of the relation between optical continuum and Balmer emission-line luminosities valid in the regime of low-luminosity AGNs.

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Radio Continuum Survey of an Optically-Selected Sample of Nearby Seyfert Galaxies

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We have used the Very Large Array (VLA) to conduct a survey for radio continuum emission in the sample of 52 Seyfert nuclei selected from the optical spectroscopic galaxy catalog of Ho, Filippenko, and Sargent. This Seyfert sample is the most complete and least biased available, and, as such, it will be useful for a variety of statistical analyses. Here we present the observations, measurements, and an atlas of radio maps.

The observations were made at 6 cm in the B-array and at 20 cm in the A-array, yielding matched angular resolutions of ∼1 arcseconds. We detected 44 objects (85%) at 6 cm and 37 objects (71%) at 20 cm above a 3 σ threshold of 0.12 mJy beam^{-1}. The sources have a wide range of radio powers ($P \approx 10^{18}$–10^{25} W Hz^{-1}), spectral indices ($\alpha_6^{20} \approx +0.5$ to -1), and linear sizes ($L \approx$ few tens pc – 15 kpc). The morphology of the radio emission is predominantly that of a compact core, either unresolved or slightly resolved, occasionally accompanied by elongated, jetlike features. Linearly polarized emission was detected at 6 cm in 12 sources, 9 of which were also detected at 20 cm.

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The Central Regions of Early-Type Galaxies Hosting Active Galactic Nuclei as Viewed with *HST*/NICMOS

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We present preliminary results from surface photometry of a sample of early-type galaxies observed with NICMOS on board *HST* in the F160W (H-band) filter. Dust is found to occur mostly in galaxies which possess unresolved nuclei, and in a few cases the presence of dust causes the isophotes to appear boxy. We performed a 2-D modeling of the host galaxy light distribution using the empirical Nuker function, which proves to be an adequate representation of the surface brightness profile for most early-type galaxies. The accurate modeling of the bulge light allows us to obtain the magnitude of the unresolved central source without contamination from the underlying stellar population. Our classification of early-type galaxies into core-type and power-law galaxies agrees with the results from previous work based on *HST* optical images, with core profiles occurring in luminous galaxies and power-law profiles occurring in low-luminosity galaxies with disky isophotes. We do not find a dichotomy in the distribution of inner slopes. Unresolved nuclear point sources are evident in about one-third of the sample galaxies, with magnitudes in the range $13.5 \leq m_H \leq 17.3$. Most of the type 1 Seyfert and LINER nuclei (83%) reveal a distinct point source, while the detection rate is much less for type 2 nuclei (35%). The occurrence of point sources appears to be independent of whether the underlying galaxy has core-type profile or power-law profile.

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Supermassive Black Holes in Bulges

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We present spatially extended gas kinematics at parsec-scale resolution for the nuclear regions of four nearby disk galaxies, and model them as rotation of a gas disk in the joint potential of the stellar bulge and a putative central black hole. The targets were selected from a larger set of long-slit spectra obtained with the *Hubble Space Telescope* as part of the Survey of Nearby Nuclei with STIS (SUNNS). They represent the four galaxies (of 24) that display symmetric gas velocity curves consistent with a rotating disk. We derive the stellar mass distribution from the STIS acquisition images adopting the stellar mass-to-light ratio normalized so as to match

ground-based velocity dispersion measurements over a large aperture. Subsequently, we constrain the mass of a putative black hole by matching the gas rotation curve, following two distinct approaches. In the most general case we explore all the possible disk orientations; alternatively, we constrain the gas disk orientation from the dust-lane morphology at similar radii. In the latter case the kinematic data indicate the presence of a central black hole for three of the four objects, with masses of $10^7 - 10^8 M_\odot$, representing up to $\sim 0.025\%$ of the host bulge mass. For one object (NGC 2787) the kinematic data alone provide clear evidence for the presence of a central black hole even without external constraints on the disk orientation. These results illustrate directly the need to determine black-hole masses by differing methods for a large number of objects, demonstrate that the variance in black hole/bulge mass is much larger than previously claimed, and reinforce the recent finding that the black-hole mass is tightly correlated with the bulge stellar velocity dispersion σ.

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