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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

Broad emission lines Lα, CIV and Hβ in the NGC 5548.

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The UV and optical spectra of active galaxy NGC 5548 were taken from the AGN Watch data base in the 1993 monitoring campaign. The spectra have chosen in the UV and optical bands, all about times of the minimum and of the maximum luminosity. The variable part of the lines exhibit two clear components, one long-ward and one short-ward of the line center. The ratios of the line intensities CIV/Lα and Lα/Hβ have been measured at seven parts of the line profiles. Analysis of the line ratios show that the CIV/Lα ratio changes from 0.5 at the wings of the lines to 1.3 - 1.4 at the center. The Lα/Hβ ratio is also low at the wings (5 - 6) but increase to 15 at the center of lines. Similar analysis for the variable part of the lines shows that the CIV/Lα ratio is ≈ 1 and the Lα/Hβ ratio is ≈ 20 along of the line profiles.

Theoretical modeling of two line ratios: CIV/Lα and Lα/Hβ has been done with the photoionization code CLOUDY. The modeling shows that the observed line ratios can be accounted for two system of clouds located at a different distances from the center. The system with a high line ratios corresponds to the HIL region with a low electron density $N_e \approx 10^{9-10}$cm^{-3}. This system emits at the central and at the variable parts of the lines (especially in the high ionization lines like Lα and CIV). It may forms above an accretion disk. The wings of the lines with a small line ratios corresponds to the LIL region with the electron density $N_e \approx 10^{12-13}$ cm^{-3}. This system located in an accretion disk and emits a significant non-variable part of the low ionization lines (like Hβ). In this case the lag obtained for the variable part of the Hβ line may not corresponds to the true distance of the LIL regions from the center. The discussed model of the NGC5548 could solve three problems: an “energy budget problem”, a “line ratio problem” and a “line variation problem” which have been put into evidence by Dumont A.-M., Collin-Souffrin S. & Nazarova L.S., 1998, A&A, 331, 11.

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XMM-Newton observations of four high-z quasars

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We present the results of XMM-Newton observations of four high-z quasars, two radio-loud and two radio-quiet. One of the radio-loud objects, PKS 2126−158, clearly shows absorption in excess of the galactic value as claimed before from ASCA and ROSAT observations. For PKS 2149−306 the evidence for excess absorption is only marginal in contrast to previous results. The location of the absorber in PKS 2126−158 is compatible with the redshift of the source. Both, a warm and a cold absorber are allowed by the X-ray data. The Lyα forest observed along the line of sight has only a low hydrogen column density which cannot account for the extra absorption. Both quasars have very flat photon spectra ($\Gamma \lesssim 1.5$) and the high photon statistics reveal small deviations from a simple power law form. For the two radio-quiet objects, Q 0000−263 and Q 1442+2931, we determine, for the first time, reliable spectral parameters. Both quasars have steeper power laws ($\Gamma \sim 2$) and show absorption consistent with the galactic value, similar to radio-quiet quasars at low redshifts. In the case of Q 0000−263 the presence of the damped Lyα system ($N(HI) \sim 2.6 \times 10^{21}$ cm^{-2} at z = 3.39) cannot be examined further due to the limited photon statistics in all instruments.

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Highly extinguished emission line outflows in the young radio source PKS 1345+12

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We present new, intermediate resolution spectra ($\sim$ 4 Å) of the compact radio source PKS 1345+12 (4C 12.50, z = 0.122) with large spectral coverage ($\sim$ 4500 Å). Our spectra clearly show extended line emission up to $\sim$ 20 kpc from the nucleus. This is consistent with the asymmetric halo of diffuse emission observed in optical and infra-red images. At the position of the nucleus we observe complex emission line profiles. Gaussian fits to the [O III] emission lines require 3 components (narrow, intermediate and broad), the broadest of which has FWHM $\sim$ 2000 km s^{-1} and is blue shifted by up to $\sim$ 2000 km s^{-1} with respect to the halo of the galaxy and HI absorption. We interpret this as material in outflow. We find evidence for high reddening and measure E(B-V) > 0.92 for the broadest, most kinematically disturbed component. This corresponds to an actual Hβ flux 130 times brighter than that observed. ¿From our model for [S II]$\lambda\lambda$6716,6731 we estimate electron densities of n_e <150 cm^{-3}, n_e >5300 cm^{-3} and n_e >4200 cm^{-3} for the regions emitting the narrow, intermediate and broad components respectively. We calculate a total mass of line emitting gas of $M_{gas} < 10^6$ $M_\odot$. Not all emission line profiles can be reproduced by the same model with [O I]$\lambda\lambda$6300,6363 and [S II]$\lambda\lambda$6716,6731 requiring separate, unique models. We argue that PKS 1345+12 is a young radio source whose nuclear regions are enshrouded in a dense cocoon of gas and dust. The radio jets are expanding through this cocoon, sweeping material out of the nuclear regions. Emission originates from three kinematically distinct regions though gradients (e.g. in density, ionisation potential, acceleration etc) must exist across the regions responsible for the emission of the intermediate and broad components.

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Discovery of a precessing jet nozzle in BL Lacertae

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We present the results of a multi-wavelength campaign during which BL Lac was observed at 17 regular epochs from 1998.23 to 2001.28. We used the VLBA in an observing mode sensitive to linear polarization at wavelength 7 mm with resolution of the order 0.2 milliarcseconds. For the first time such observations were complemented by near-simultaneous polarization-sensitive JCMT observations at a wavelength close to 1 mm. Optical polarimetry was also obtained for the final year of observations. The VLBA images reveal a remarkable oscillating 'nozzle' structure with a period of ∼2 years. The orientation of the nozzle tracks the polarization position angle measured at the JCMT, in which we detect a very similar period. We argue that these results require the same jet direction at the small scale probed by the 1 mm emission as at the larger scale probed by the 7 mm emission; there is no evidence to suggest wiggling of the jet between these scales. The picture that emerges is of a straight but precessing jet whose components form a straight line near the core, but form an apparently curved locus at larger separations where components were ejected in different directions. Two further lines of evidence support this view. First, tracing the evolution of bright components showed straight paths and ejection angles consistent with the nozzle direction at the ejection time. Second, a simple model of a precessing nozzle was used to predict the inner jet structure. At most epochs the agreement between the model and data was good. On angular scales > 2 milliarcseconds from the core a transition occurs and most components bend to follow the usual south-easterly direction on deca-milliarcsecond scales. This precession is clearly analogous to that found in the galactic jet source SS 433 albeit with a higher jet speed and a smaller precession cone opening-angle. The precession observed in SS 433 is believed to be due to the interaction of a companion star with the accretion disk around the compact object. This suggests the possibility that the black hole from which BL Lacertae's jet emerges is part of a binary system.

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Ultraviolet and optical properties of Narrow-Line Seyfert 1 galaxies

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Narrow Line Seyfert 1 (NLS1) galaxies are remarkable for their extreme continuum and emission line properties which are not well understood. New results bearing on the spectroscopic characteristics of these objects are presented here, with the aim of establishing their typical ultraviolet (UV) and optical spectral behavior. We employ *Hubble Space Telescope* (*HST*) observations of 22 NLS1s, which represent a substantial improvement over previous work in terms of data quality and sample size. High signal-to-noise (S/N) NLS1 composite spectra are constructed, allowing accurate measurements of the continuum shape and the strengths, ratios, and widths for lines, including weak features which are barely identifiable in other Active Galactic Nuclei (AGN) composites. We find that the NLS1 sources have redder UV-blue continua than those typically measured in other quasars and Seyferts. Objects with UV line absorption show redder spectra, suggesting that dust is important in modifying the continuum shapes. The data also permit a detailed investigation of the previously proposed link between NLS1s and $z \gtrsim 4$ quasars. Direct comparison of their composite spectra, as well as a Principal Component Analysis, suggest that high-z QSOs do not show a strong preference toward NLS1 behavior.

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Spectroscopy of the near-nuclear regions of Cygnus A: estimating the mass of the supermassive black hole

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We use a combination of high spatial resolution optical and near-IR spectroscopic data to make a detailed study of the kinematics of the NLR gas in the core region of the powerful, FRII radio galaxy Cygnus A ($z = 0.0560$), with the overall goal of placing limits on the mass of any supermassive black hole in the core. Our K-band infrared observations (0.75 arcsec seeing) – taken

with NIRSPEC on the Keck II telescope – show a smooth rotation pattern across the nucleus in the Paα and H_2 emission lines along a slit position (PA180) close to perpendicular to the radio axis, however, there is no evidence for such rotation along the radio axis (PA105). Higher spatial resolution observations of the [OIII]λ5007 emission line – taken with STIS on the Hubble Space Telescope (HST) – confirm the general rotation pattern of the gas in the direction perpendicular to the radio axis, and provide evidence for steep velocity gradients within a radius of 0.1 arcsec of the core — corresponding to the high surface brightness structure visible in high resolution narrow band images. The [OIII] line remains broad throughout the core region ($FWHM \sim 300 - 900$ km s^{-1}), but the spatial distribution of [OIII] provides no evidence for an unresolved inner narrow line region (INLR). Assuming that the ionized gas is circularly rotating in a thin disk and that the large line widths are due to activity-induced turbulence, the circular velocities measured from both the Keck and HST data lead to an estimate of the mass of the supermassive black hole of $2.5 \pm 0.7 \times 10^9 \mathrm{M}_\odot$. For the host galaxy properties of Cygnus A, this mass is consistent with the global correlations between black hole mass and host galaxy properties deduced for non-active galaxies. Therefore, despite the extreme power of its radio source and the quasar-like luminosity of its AGN, the black hole in Cygnus A is not unusually massive considering the luminosity of its host galaxy. Indeed, the estimated mass of the black hole in Cygnus A is similar to that inferred for the supermassive black hole in the FRI radio galaxy M87, despite the fact that Cygnus A is 3 orders of magnitude more powerful at radio wavelengths. Overall, these results are consistent with the idea that the properties and power of the radio jets in radio galaxies are determined as much by the accretion rate, as by the absolute masses of their supermassive black holes.

As well as providing evidence for a supermassive black hole in the core of Cygnus A, our data also demonstrate that nuclear activity has an important effect on the kinematics of the circum-nuclear gas on a sub-kpc scale. Most notably, the velocity offsets measured in the two outer HST/STIS slit positions are consistent with the presence of an activity-induced outflow in the NW cone.

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Spectral Slope Variability of BL Lac Objects in the Optical Band

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Light curves of eight BL Lac objects in the BVRI bands have been analyzed. All of the objects tend to be bluer when brighter. However spectral slope changes differ quantitatively from those of a sample of QSOs analyzed in a previous paper Trévese & Vagnetti (2002) and appear consistent with a different nature of the optical continuum. A simple model representing the variability of a synchrotron component can explain the spectral changes. Constraints on a possible thermal accretion disk component contributing to the optical luminosity are discussed.

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Jet-Gas Interactions in Markarian 78 – I : Morphology and Kinematics

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We present a detailed study of the Seyfert 2 galaxy Markarian 78, using continuum and emission line images and multiaperture spectra from HST, and a deep 3.6 cm VLA image. Our overall aim is to study the interaction between the radio source and the emission line gas, since ground based data already indicate the presence of a strong bi-polar jet driven flow.

First, in the wider context, Mkn 78 is probably a post-merger system, with nuclear dust lane, approximate $r^{1/4}$ continuum profile, and highly extended asymmetric gas distribution.

The [OIII] and radio images both show complex structures with many similarities but also important differences. A careful comparison shows convincing *morphological* evidence for jet-gas interaction; (a) the western inner radio jet terminates and flares at the position of a bright [OIII] knot; (b) the weaker eastern radio jet changes direction as it encounters a large [OIII] knot; (c) most [OIII] features appear limb brightened on the upstream side, and flared on the downstream side; (d) in the outer regions the radio components tend to lie between or adjacent to [OIII] knots, indicating the radio and line emitting phases do not easily intepenetrate. In addition to evidence of jet-gas interaction, two features indicate the importance of a central ionizing radiation field: an inner fan-like structure to the east, with a straight kinematically quiet northeast edge; and an approximately fan-like Extended Narrow Line Region to the west, lying well outside the radio source.

[OIII] line profiles from 10 FOS apertures provide further *kinematic* insight into the jet-gas interaction. (1) On the eastern side, where the radio source is deflected, the [OIII] profile contains a highly redshifted component ($\sim$ 700 km s^{-1}) which is also *narrow* (FWHM $\leq$ 200 km s^{-1}), indicating significant coherent gas acceleration with almost no induced turbulence; (2) At this location the [OIII] profile is also double, suggesting lateral expansion away from a jet axis, as it burrows into the cloud complex; (3) In contrast, the bright western inner knot, which seems to disrupt the inner radio jet, has essentially undisturbed kinematics. (4) Across the outer complex western region, gas velocities are higher in the region center, decrease at the leading edge and may be highest where radio flows 'blow out' of the region.

Overall, morphology and kinematics suggest the western side is best described as an initially disrupted jet which then fills, accelerates, and leaks out of a complex incomplete 'bubble' of ionized gas. The eastern side is best described as a large centrally illuminated fan-like gas structure which is penetrated, accelerated, and ultimately deflects the radio source. We use these different regions to construct a plausible evolutionary sequence : Initially, a dense (molecular ?) cloud enters the jet flow and disrupts it (inner western knot); as time passes, the jet begins to penetrate, accelerate and ablate the cloud (eastern knot complex); continued jet influence further disperses the cloud fragments, sweeping out channels and gaps (western lobe region). This process may repeat itself many times over the lifetime of the jet.

In companion papers, we study the velocity field and ionization mechanisms in more detail using recently aquired STIS spectra, taking a more complete account of the energetics of the radio source, the ionized gas and the extended blue continuum.

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INTEGRAL spectroscopy of three powerful radio galaxies: Jet-cloud interactions seen in 3-D

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Integral-field spectroscopic observations are presented for three powerful radio galaxies, namely 3C277.3 (Coma A; z=0.0857), 3C171 (z=0.2384) and 3C265 (z=0.811), which are known to be undergoing jet-cloud interactions. The morphology, kinematics and ionization of the gas in the emission-line structure of these sources are mapped and analysed. One-dimensional spectra are also extracted and integrated over the different emission-line regions in each galaxy.

In two of the galaxies (3C277.3 and 3C171) the radio sizes are of similar extent to the emission-line structure. For these, enhanced emission-line regions are found associated with the radio structures, in addition to complex kinematics and low ionization states close to the radio hotspots, indicating that jet-induced shocks disturb and ionize the gas. Interestingly, the bright — presumably shock-ionized — emission-line region coincident with the radio jet knot in 3C277.3 shows quiescent kinematics and high ionization state. Possible explanations for this puzzling result are proposed.

The images of 3C171 and 3C265 indicate that the lateral expansion of the cocoon has a significant effect on the kinematics and ionization of the gas, showing for the first time that the effects of the radio source are felt far from the jet axis.

In addition, the presence of a stellar-photoionized HII region is detected in the extended emission-line nebula of the radio galaxy 3C277.3.

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Quasar Elemental Abundances at High Redshifts

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We examine rest-frame ultraviolet spectra of 70 high redshift quasars ($z \geq 3.5$) to study the chemical enrichment history of the gas closely related to the quasars, and thereby estimate the epoch of first star formation. The fluxes of several ultraviolet emission lines were investigated within the framework of the most recent photoionization models to estimate the metallicity of the gas associated with the high-z quasars. Standard photoionization parameters and the assumption of secondary nitrogen enrichment indicate an average abundance of $Z/Z_{\odot} \simeq 4$ to 5 in the line emitting gas. Assuming a time scale of $\tau_{evol} \simeq 0.5 - 0.8$ Gyrs for the chemical enrichment of the gas, the first major star formation for quasars with $z \simeq 4$ should have started at a redshift of $z_f \simeq 6 - 8$, corresponding to an age of the universe of several 10^8 yrs ($H_o = 65$ km s^{-1} Mpc^{-1}, $\Omega_M = 0.3$, $\Omega_\Lambda = 0.7$). We note that this also appears to be the era of re-ionization of the universe. Finally, there is some evidence for a positive luminosity – metallicity relation in this high redshift quasar sample.

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Location of H_2O maser in the double-nuclei system of NGC 6240

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We performed VLA observations of the 22 GHz H_2O maser emission in the merging galaxy NGC 6240, which hosts the well-known double active nuclei. In a previous paper, we reported on the first solid detection of the H_2O maser emission in 2001. After two abortive attempts due to the weakness and probable variability of the emission, the maser was detected with the VLA in June 2002. The emission is unresolved at ~ 0.3 arcsecond and coincides with the southern 22 GHz continuum peak to ~ 0.007 arcsecond (~ 3 pc: D = 97 Mpc). The detection of the maser in the southern nucleus indicates that nuclear activity of the galaxy, which is significant in X-ray and far-infrared (FIR) bands, lies mainly in the southern nucleus, and the nucleus without a high brightness peak could be explained by thick dust emitting FIR radiation. We favour the idea that the maser in NGC 6240 is associated with the AGN-activity.

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The Far-Infrared Spectral Energy Distributions of X-ray-selected Active Galaxies.

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Hard X-ray selection is, arguably, the optimal method for defining a representative sample of active galactic nuclei (AGN). Hard X-rays are unbiased by the affects of obscuration and re-processing along the line-of-sight intrinsic/external to the AGN which result in unknown fractions of the population being missed from traditional optical/soft-X-ray samples. We present the far-infrared (IR) observations of 21 hard X-ray selected AGN from the HEAO-1 A2 sample observed with ISO. We characterize the far-infrared (IR) continua of these X-ray selected AGN, compare them with those of various radio and optically selected AGN samples and with models for an AGN-heated, dusty disk. The X-ray selected AGN show broad, warm IR continua covering a wide temperature range ($\sim 20-1000$ K in a thermal emission scenario). Where a far-IR turnover is clearly observed, the slopes are < 2.5 in all but three cases so that non-thermal emission remains a possibility, although the presence of cooler dust resulting in a turn-over at wavelengths longwards of the ISO range is considered more likely. The sample also shows a wider range of optical/UV shapes than the optically/radio-selected samples, extending to redder near-IR colors. The bluer objects are type 1 Seyferts, while the redder AGN are mostly intermediate or type 2 Seyferts. This is consistent with a modified unification model in which obscuration increases as we move from a face-on towards more edge-on line-of-sight (l.o.s.) However, this relation does not extend to the mid-infrared as the 25μm/60μm ratios are similar in Seyferts with differing type and optical/UV reddening. The resulting limits on the column density of obscuring material through which we are viewing the redder AGN ($N_H \sim 10^{22}$ cm^{-2}) are inconsistent with standard optically thick torus models ($N_H \sim 10^{24}$ cm^{-2}) and simple unification models. Instead our results support more complex models in which the amount of obscuring material increases with viewing angle and may be clumpy. Such a scenario, already suggested by differing optical/near-IR spectroscopic and X-ray AGN classifications, allows for different amounts of obscuration of the continuum emission in different wavebands and of the broad emission line region which, in turn, results in a mixture of behaviors for AGN with similar optical emission line classifications. The resulting decrease in the optical depth of the obscuring material also allows the AGN to heat more dust at larger radial distances. We show that an AGN-heated, flared, dusty disk with mass $\sim 10^9$ $M_\odot$ and size $\sim$few hundred pc is able to generate optical$-$far-IR spectral energy distributions (SEDs) which reproduce the wide range of SEDs present in our sample with no need for an additional starburst component to generate the long-wavelength, cooler part of the IR continuum.

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Continuum and spectral line emission of the OH Megamaser galaxy Arp 220

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We present MERLIN observations of the continuum (both 1.6 and 5 GHz) and OH maser emission towards Arp 220. The correct spatial configuration of the various components of the galaxy is revealed. In the eastern component the masers are shown to be generally coincident with the larger-scale continuum emission; in the west, the masers and continuum do not generally arise from the same location. A velocity gradient ($(0.32\pm0.03)\,\mathrm{km\,s^{-1}pc^{-1}}$) is found in the eastern nuclear region on MERLIN scales; this gradient is three times smaller than that seen in HI and implies that the OH gas lies inside the HI. A re-analysis of previously presented global VLBI data (Lonsdale et al. 1998) reveals a very high velocity gradient ($(18.67\pm0.12)\,\mathrm{km\,s^{-1}pc^{-1}}$) in one component, possibly the site of a heavily obscured AGN.

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Meetings

Science with Adaptive Optics

ESO Workshop

September 16-19, 2003

Garching (near Munich), Germany

Over the past ten years, the concept of adaptive optics has matured from early experimental stages to a standard observing tool now available at many large optical and near-infrared telescope facilities. Indeed, adaptive optics has become an integral part of all present and future large telescope initiatives, and will be essential in exploiting the full potential of the large optical interferometers currently under construction. Adaptive optics has been identified as one of the key technologies for astronomy in the 21st century. Adaptive optics has already delivered exciting results covering areas from solar system astronomy (both the sun and the planetary system) over the star forming regions in the solar neighbourhood to Local Group galaxies and objects at cosmological distances. Recent highlights include:

- Evolution of small scale structures on the solar surface
- Discovery of binary asteroids and asteroids moons
- High-resolution studies of circumstellar disks around young stars
- Precise mass determination of the black hole in the Galactic Center
- Spatially resolved studies of extragalactic stellar populations

The present meeting intends to bring together users of adaptive optics from all fields of astronomy to discuss the latest scientific results obtained with diverse adaptive optics systems and to exchange ideas on how to reduce and analyse such observations.This ESO workshop aims also at educating the general astronomical community in Europe on the unique science potential of adaptive optics for all branches of astronomy. We want to bring together researchers working in many different areas of astronomy in order to provide a comprehensive picture of the utilisation of adaptive optics in astronomy. Synergy effects are expected from the comparison of different observing and data analysis strategies.

Scientific Organizing Committee:
Co-chairs: Wolfgang Brandner (MPIA), Markus Kasper (ESO)
Danielle Alloin (ESO), Laird Close (Steward Obs., Tucson, USA), Tim Davidge (Herzberg Inst., Victoria, Canada), Reinhard Genzel (MPE, Germany), Thomas Henning (MPIA, Germany), Christoph Keller (NSO Tucson, USA), Anne-Marie Lagrange (LAOG, France), Simon Morris (Durham, UK), Francois Rigaut (Gemini, USA), Daniel Rouan (Obs. de Paris, France), Hans Zinnecker (AIP, Germany)

For more details and registration, see **http://www.eso.org/aoscience03**

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Dissertations

Properties of Galactic Nuclei Inferred From Line Spectra

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This work explores how certain properties of galactic nuclei can be understood on the basis of the available data. Current evidence for the presence of large central masses in these regions, believed to be supermassive black holes, is first reviewed. Methods for estimating the mass are discussed, and a new algorithm is presented for implementing reverberation techniques with time-variable broad line data from active nuclei. The effectiveness of this new algorithm is first tested on sample data sets; it is then applied to actual data. Next, a model is presented for the formation of the cool, dense clouds responsible for the broad line emission, involving the rapid cooling of shocked gas embedded in a quasi-spherical, turbulent accretion flow. As an illustrative example, fitting of the model (with simplify assumptions) is performed on data pertaining to the Seyfert nucleus NGC 5548.

Accretion flows in two specific objects are then discussed. First, a cool, spherical accretion flow is argued for the non-active nucleus of M31 on the basis of the observed broad-band spectrum. In addition to comparisons of the model with the currently available data, we provide detailed predictions of the UV and optical line spectra, correcting for extinction due to intervening dust and cold gas. Then, a turbulent disk structure is argued for the weakly-active nucleus in the radio galaxy NGC 4261. This structure is capable of producing both the observed broad line spectrum and radio absorption, and may have application to the nuclei of other radio galaxies.

Finally, the iron Kα emission from Sgr B2, a giant molecular cloud located in the Galactic Center region, is reviewed. While many argue that this suggests recent activity associated with the radio source Sgr A*, our modeling indicates that the data are also consistent with a time-variable illuminator embedded within the cloud.

The observations and modeling suggest that turbulence may be a key component to accretion in active nuclei, facilitating the transfer of angular momentum and allowing the greater accretion rates needed to fuel the central engines. Future 3D-hydrodynamical simulations are required to test this assertion.

The Active Galaxies Newsletter is available on the World Wide Web. You can access it via the University of Manchester home page :- http://www.ast.man.ac.uk/~rb/agn/
If you move or your e-mail address changes, please send the editor your new address. If the Newsletter repeatedly bounces back from an address then that address is deleted from the mailing list.