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Conference Proceedings

Gamma-Ray Emitting AGN

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A workshop on 'Gamma-ray emitting AGN' was held in the Landessternwarte Heidelberg-Königstuhl in October 1996. The meeting was attended by some 60 participants and all but one of the 34 contributions on the topics MeV – GeV Gamma-Rays, TeV Gamma-Rays, Multifrequency Aspects, Variability, and Models are collected in the proceedings (178 + 9 pages).

The electronic version of the proceedings is available at http://www.lsw.uni-heidelberg.de/projects/extragalactic/

Abstracts of recently accepted papers

IR emission-line signatures of Tori in the nuclei of Seyferts

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We present infrared (IR) long-slit spectroscopy of two galaxies with Seyfert 2 nuclei: NGC 2110 and the Circinus galaxy, which are known from previous studies to exhibit anisotropic high excitation gaseous emission. In the Unified Model scenario for Seyferts, this anisotropy is due to collimation of the ionizing nuclear radiation by an optically thick molecular torus which surrounds the nucleus. We have looked for signatures of this torus and its collimating effect in the IR (J and K bands), taking advantage of the reduced relative attenuation at these wavelengths. The two galaxies are found to present extended emission in the lines [FeII]$\lambda 1.257\mu$m, Paβ, $H_2\lambda 2.12\mu$m and Brγ, both along the collimation axis as well as perpendicular to it. The [FeII] line is found to trace the high excitation emission, and, in the case of NGC 2110, is more extended along the collimation axis. The H_2 emission, although consistent with the presence of a molecular torus, extends for hundreds of parsecs and the derived kinematics is consistent with circular rotation in the plane of the galaxies. The emission line ratios [FeII]/Paβ and H_2/Brγ are much smaller in Circinus (respectively ~ 0.5 and 1) than in NGC 2110 (~ 7 and ≥ 4) and evidence the presence of a nuclear starburst in the former galaxy. IR rotation curves were determined for both galaxies. In the case of NGC 2110, the rotation curve shows a different behavior from one determined using optical lines, evidencing the importance of obscuration effects in the study of the gaseous kinematics.

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Transient Double-Peaked Line Emission as Signatures of Accretion Events Around Supermassive Black Holes

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We discuss the recent appearance of very broad (FWZI$\sim$20000 km s^{-1}) double-peaked Balmer emission lines in the nuclei of the galaxies NGC 1097, Pictor A and M 81. Such profiles are rare, and only found in about 10% of broad-line radio galaxies. In the most accepted scenario, they are the signature of relativistic gas motions around a supermassive nuclear black hole. We make a parallel between the properties of the above three nuclei: while Pictor A is a radio-galaxy similar to the others where the double-peaked profile is found, NGC 1097 and M 81 are low-luminosity nuclei located in spiral hosts. The latter galaxies nevertheless share the key characteristics of more powerful radio galaxies with double-peaked lines: narrow emission-line ratios typical of LINERs, double-peaked Balmer lines which are on average twice as broad as those of typical radio loud AGN and the presence of jets. These properties suggest that low-luminosity LINERs harbor similar nuclear engines as the most luminous active galactic nuclei (AGN), only less powerful. In these less powerful AGN, it is more easy to witness individual accretion events. Here we propose that the transient double-peaked lines are due to such events producing transient accretion disks around a supermassive nuclear black hole. We discuss, in particular, the case of NGC 1097, for which we show that the double-peaked profile and its variation over a time interval of $\sim$ 4 years can be well reproduced by a model of an elliptical accretion ring which could have formed from the debris released by the disruption of a star by a nuclear supermassive black hole.

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Ultraviolet variability of the Seyfert 1 galaxy Fairall–9

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The large amplitude of the variations of the Seyfert I Galaxy Fairall–9 between 1978 and 1991 make this Active Galaxy especially suitable for a combined study in terms of reverberation analysis and photoionization modeling over the velocity field of the broad lines of its ultraviolet spectrum. We have combined our ultraviolet data with those available at other wavelengths to derive the intrinsic ionizing continuum and to compare the predictions of the photoionization models with the observations. The UV continuum varies with a factor of 33±4 on a characteristic time scale of 182 $days$. The intrinsic spectral index UV–optical is α=–0.07±0.02 and the optical variations do not lag behind the UV variations at the mean sampling interval of 96 days. In the near IR, the J band flux presents a direct extension of the UV–optical continuum (α_{J-UV}=–0.07±0.05). Only at low flux levels is the 2–10 keV flux proportional to the UV continuum, at higher UV flux levels proportionality between the X–Rays and the UV brightness breaks down. The continuum spectral energy distribution (SED) of the nucleus supports the previously reported FIR–NIR excess associated with 0.02 $M_\odot$ dust at a distance of some 400±100 $light-days$, as well as a soft X–Ray excess, possibly associated with the reprocessing on an accretion disk of the hard X–Rays emitted from a region above the disk. The presence of strong Fe Kα line in the GINGA spectra of this galaxy does lend support to this model.

Line profile variability has been used to isolate four gaussian line components, which are sufficient to describe all lines at all levels of brightness in a consistent way: one narrow (i.e. unresolved at the IUE resolution), and three broad components : a central (velocity same as the narrow line), a red shifted (v=3300 $km\ s^{-1}$) and a blue shifted (v=–3600 $km\ s^{-1}$) one. The three broad components are strongly correlated with the UV continuum, indicating that photoionization is the dominant mechanism in the BLR. Correlation analysis shows different delays between the broad components and the UV continuum: respectively, 400±100, –4±70 and 230±95 $days$ for the central, red and blue one. Only the red component of Ly$\alpha\lambda$1216 and CIVλ1549 appear to vary linearly with the continuum and give significant transfer functions. The resulting transfer functions are peaked at zero days

delay and are unresolved at the average time resolution (96 days) of our data. The photoionization models (CLOUDY) applied to the line ratios in these components, indicate that the Broad–Line–Region (BLR) is situated between 50–250 light-days from the ionizing source, with an hydrogen density of 10^{12-10} cm^{-3}, a column density of 10^{23-26} cm^{-2} and a covering factor of 12–2%, with an ionization parameter between 0.003 and 0.089. However, no optically thick model reproduces the $Ly\alpha$/CIV and $Ly\alpha$/NV ratios. From these results we propose a model for the structure and dynamics of the BLR: the mass of the central compact object is $M \approx 2{\times}10^{8}$ $M_{\odot}$. Around this exist two distinct gas zones within the BLR: the gas producing the central component at ≈200 light-days and gas, emitting the red and the blue components, at ≈80 light-days moving inward to a central source. These results require that both these gas zones be localized along the line–of–sight or, alternatively, that the continuum emission must be strongly anisotropic. Besides, the gas emitting the central component is most likely mixed with the dust and the central gas to dust mass ratio is Mass (central gas)/mass(dust)=100–750.

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Properties of warm absorbers and constraints from their optical and UV line emission

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We have studied the warm absorbers in several Seyfert galaxies using ROSAT X-ray data. The parameters that govern the emissivity of the ionized material, ionization parameter U and warm column density $N_{\rm w}$, are determined from X-ray spectral fits. These are then used to predict the expected IR to UV line emission of the ionized material in the individual objects. In particular, the possibility of a warm-absorber origin of one of the known emission line regions in AGN is assessed, good 'candidate components' being e.g. the coronal line region, and/or the high-ionization component of the NLR, or the component responsible for broad wings in the Balmer lines.

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The ionization mechanism of the extended gas in high redshift radio galaxies: shocks or AGN photoionization?

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We have compared the UV line ratios of a sample of very high redshift radio galaxies (HZRG, $z > 1.7$) with shock and active galactic nuclei (AGN) photoionization models, with the goal of determining the balance between jet-induced shocks and AGN illumination in the extended emission line regions (EELR). We find that the UV line ratios cannot be explained in terms of photoionization of solar abundance gas by the classical power law of index α =-1.5, which successfully reproduces the general trends defined by the optical line ratios of low redshift radio galaxies. Pure shock models also provide a poor fit to the data. However, photoionization by a power law of index -1.0 provides an excellent fit to the UV line ratios. This suggests that the ionizing continuum spectral shape may depend on radio luminosity and/or redshift, such that it becomes harder as the radio power and/or redshift increase. However, an alternative possibility is that we are seeing the first signs of chemical evolution in these objects, since a power-law of index -1.5 with low metallicity also provides a very good fit to the data.

For the high ionization conditions found in the the HZRG, we show that the power-law photoionization models provide a better fit to the data than the shock models. However, such is the complexity of the shock models that we cannot rule out the possibility that a different combination of input parameters can reproduce the observed spectra.

We further show that the UV line ratios provide a sensitive test of the ionization mechanism for the lower ionization ns prevalent in some low redshift jet-cloud interaction candidates. For high ionization parameter this discrimination is difficult due to the overlap of k and power law photoionization models.

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The Nature of the Broad–Line–Region in the Radio–Loud AGN 3C390.3

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We present the results of an analysis of the ultraviolet and X–Ray variability of the Broad–Line–Radio Galaxy 3C390.3 over 15 years. The UV continuum of 3C390.3 showed large variations with amplitudes of up to a factor of 10. We find:

(1) The variations of CIV and $Ly\alpha$ are highly correlated with the UV continuum, and are delayed with respect to the continuum variations by 50–110 days with the red wing of both CIV and $Ly\alpha$, leading the blue wing;

(2) The CIV/$Ly\alpha$ ratio is positively correlated with both the continuum flux and UV line strength, a behavior different from other AGNs studied so far;

(3) The blue sides of the $Ly\alpha$ and CIV profiles are similar to the blue side of the Balmer lines, while the red sides are different, suggesting a different origin for the red peak in the Balmer lines.

The X–Ray spectra of 3C390.3 observed with ROSAT can be well fitted by a single power-law at Galactic absorption with a spectral slope of $\alpha = 0.9$. The overall optical, UV to X–Ray spectrum can also be described by a single power law with $\alpha_{uvx} = 0.89$, indicating a very weak or no big blue bump. The unusual behavior of CIV/$Ly\alpha$ variations might be related to this hard ionizing continuum in 3C390.3.

Our results suggest: (1) The broad CIV and $Ly\alpha$ emitting gas is infalling towards the central object in 3C390.3; (2) The overall behaviour of the CIV/$Ly\alpha$ ratio and the absence of a big blue bump, strongly indicate the coexistence of optically thick as well as optically thin BLR clouds; (3) Assuming circular symmetry and predominantly circular motion, the BLR gas is situated at 83±25 lightdays from the central source; (4) Under these assumptions and with the derived circular velocity of $v_{rot} \simeq 2850$ km s^{-1}, the central mass inside this radius is confined to 1.3 $10^8 M\odot < M_{CM} < 4.0\ 10^8 M\odot$; (6) Comparing our results with those obtained from VLBI and observations of the Fe $K\alpha$ line, suggests the association of the BLR with a disk, inclined at 98±12 degrees with respect to the direction of superluminal motion of the radio blobs.

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Infrared imaging and off-nuclear spectroscopy of quasar hosts

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We present the results of two complementary ground-based programmes to determine the host galaxy properties of radio-quiet and radio-loud quasars and to compare them with those of radio galaxies. Both infrared images and optical off-nuclear spectra were obtained and we discuss the various strategies used to separate the quasar-related emission from that of the underlying galaxy. However, the key feature of this project is the use of carefully matched samples, which ensure that the data for different types of object are directly comparable.

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The radio properties of radio-quiet quasars

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Although radio-quiet quasars (RQQs), which constitute the majority of optically-identified quasar samples, are by no means radio silent the properties of their radio emission are only poorly understood. We present the results of a multi-frequency VLA study of 27 low-redshift RQQs. In general, we find that the properties of the radio sources in RQQs are consistent with them being weak, small-scale ($\sim$ 1 kpc) jets similar to those observed in nearby Seyfert galaxies. We conclude that a significant fraction of the radio emission in RQQs is directly associated with the central engine and is not a result of stellar processes in the surrounding galaxy. There appears to be no difference between the radio properties of RQQs in elliptical and disc galaxies, implying that the relationship between the host galaxy and the 'radio loudness' of the active nucleus is not straightforward.

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