Multiband Approach to AGN

The Second RadioNet Science Workshop

ABSTRACT BOOK

Max-Planck-Institut für Radioastronomie
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Talks

Session I: AGN across the Spectral Bands

The Relationship between Radio and Higher-Frequency Emission in AGNs *(review)*

Alan P. Marscher

Boston University

I will review the radio emission observed in active galactic nuclei and the physical conditions that cause it. The populations of highly relativistic electrons that produce radio synchrotron radiation can also generate variable infrared and optical synchrotron emission as well as high X-ray and gamma-ray fluxes. The high-energy emission from these relativistic electrons will tend to dominate the observed luminosity at sites that are compact and/or collimated into highly relativistic outflows, i.e., mainly in the jets we see on milliarcsecond and arcsecond scales. Multiwaveband monitoring and imaging programs have established that high-energy emission does indeed occur in the radio-bright sections of jets in AGNs. The connection between the central engine and the radio jets, which are first detected parsecs downstream in powerful AGNs, is more difficult to establish. However, we are beginning to see that some of the phenomena found in Seyfert galaxies and black-hole binaries - X-ray dips and flaring of the "relativistic" red wing of the Fe K-alpha X-ray emission line - are associated with the release of extra energy into the jet. Furthermore, VLBI observations of radio galaxies suggest that the collimation and acceleration of jets occurs over a region extended over hundreds of Schwarzschild radii or more. Such observations help to guide the development of theoretical models for the acceleration and focusing of the jets and link disturbances in the jet with events in the accretion disk and its surroundings. An intriguing question surrounds the relationship between the X-ray, optical, and radio emission in jets observed on arcsecond scales in quasars. The radiation mechanism is either synchrotron emission from extremely energetic (tens to hundreds of TeV) electrons or inverse Compton scattering of cosmic microwave background photons by quite low-energy (less than 100 MeV) electrons. Since the energies of the radio-emitting electrons fall in between (1-100 GeV), they should be either much more weakly or strongly affected by radiative energies losses. At present, it appears that both synchrotron and inverse Compton X-rays are seen on arcsecond scales, with some rather interesting cases of very low magnetic fields and extremely relativistic bulk motions out to hundreds of kiloparsecs from the nucleus. The multiwaveband approach has proven extremely valuable in our attempts to interpret AGNs. We need to promote the development of new instruments and the enhancement of current telescopes in order to improve our ability to image and monitor AGNs across the electromagnetic spectrum.

Radio Observations, The Best Way towards an Unbiased Sample of Quasars

Robert Becker

UC-Davis/LLNL

Deep blind radio surveys are the best way to create an unbiased sample of quasars.I will present our current results from the VLA FIRST survey and speculate about the next generation of radio surveys.

Optical view of AGN *(review)*

Christian Wolf

Oxford University

I will review the current optical view of AGN.

Radio-Optical scrutiny of the central engine in compact AGN

T.G.Arshakian[1], V.H.Chavushyan[2], E.Ros[1], A.J.Zensus[1], M.Kadler[1]

1 - MPIfR (Bonn, Germany), 2 - INAOE (Puebla, Mexico)

We have been carrying out optical spectral observations of 172 active galactic nuclei (AGN) from the 2 cm Very Large Baseline Array (VLBA) survey to investigate the relationship between the parsec-scale radio jets of AGN, their central engines, and the emission-line regions. All radio sources are flat-spectrum AGN with relativistic jets aligned with the line of sight. Here, we present the diversity of spectral types among the brightest AGN in our sample, and discuss correlations between the properties of the radio jet and spectroscopic signatures of the central engine for ~ 30 compact AGN.

Infrared interferometry of AGN: Present interferometric results and future goals

G. Weigelt

MPIfR, Bonn

We discuss the present results and future goals of near-infrared interferometry of AGN. We show that infrared interferometry is able to resolve the innermost region surrounding the accretion disk, for example, the dust near the walls of an inner, low-density outflow cavity or in the innermost region of a parsec-scale dusty torus as well as related structures. The nearest AGN are very important candidates for testing the predictions of unification schemes of AGN. One of the nearest and brightest Seyfert galaxies is NGC 1068. During the last few years speckle interferometric observations, adaptive optics, and long-baseline interferometry of the dust environment of NGC 1068 have been reported. H- and K'-band bispectrum speckle interferometry studies of the nuclear region of NGC 1068 with the SAO 6 m telescope allowed the reconstruction of a diffraction-limited K'-band image with 74 mas resolution and the first H-band image with 57 mas resolution. The compact core has a north-western, tail-shaped extension. The K'-band FWHM diameter of this compact core is 18 x 39 mas (+/- 4 mas) or 1.3 x 2.8 pc, and the P.A. of the north-western extension is -16 degree. This P.A. is very similar to that of the western wall of the bright region of the ionization cone. This suggests that the H- and K'-band emission from the compact core is both thermal emission and scattered light from dust near the western wall of a low-density, conical cavity or from the innermost region of a parsec-scale dusty torus that is heated by the central source (the dust sublimation radius of NGC 1068 is approximately 0.1 - 1 pc). Finally, first long-baseline interferometry of NGC 1068 in the near-infrared K band (VINCI beam combiner instrument) and in the mid-infrared (MIDI beam combiner) have been carried out with two 8.2 m Unit Telescopes of ESO's VLT Interferometer. The VINCI K-band observations show that the squared visibility amplitude of NGC 1068 is approximately 0.16 at a projected baseline of 46 m. This visibility corresponds to a substructure of less than 5 mas or 0.4 pc.

X-ray view of AGN *(review)*

Diana Worrall

University of Bristol

In the years since Seyfert galaxies and quasars were first discovered through optical and radio techniques, high-energy emission has become the defining characteristic of an AGN. Current X-ray missions are sufficiently sensitive at high energies to detect AGNs behind large intrinsic gas column densities, and so to test unified models. Grating spectroscopy can resolve even quite narrow Fe Kα lines, so associating them with an accretion disk or gas torus. AGNs with extended radio jets are of particular interest, since the jets signal source orientation. However, the jets extend into the cores, where they are faster and more compact. Special-relativistic effects

then cause jet brightness and variability time-scales across the electromagnetic spectrum to be strong functions of jet orientation. Jet X-ray emission is confused, to varying degrees, with that from the central engine, but can be measured, at least in a statistical sense, through considerations of the multiwaveband spectrum and the level of intrinsic absorption. The rich high-energy structures found in jets which are resolved with Chandra and HST inform our interpretation of the inner structures. In particular, it is found that shocks are prevalent and don't necessarily disrupt jets, and one-zone models of emission near shocks are an over-simplification.

Connection between X, UV and optical emission line regions of Active Galactic Nuclei

Luka C. Popovic[1,2]

1 – Astronomical Observatory Belgrade, Belgrade, Serbia; 2 – Astrophysical Institute Potsdam, Germany

The emission lines of Active Galactic Nuclei (AGN) are produced over a wide range of distances from the central continuum source, and under a wide range of physical and kinematical conditions. The line strength, their width and shape are the powerful tool for emitting gas diagnostic in the different parts of emitting region of AGNs. The different types of the physical conditions and processes can be assumed in order to use the emission lines for diagnostic of emission plasma. Here, we analyze the Fe K_α (X-ray), Ly_α, CIV and Mg II (UV-lines) and H_β, H_α (optical) lines of several AGNs in order to investigate similarity and differences between X-ray, UV and optical line emission regions.

Session II: AGN across the Luminosity Range

Accretion processes and SMBH *(review)*

Andrew King

University of Leicester

Accreting black holes of all masses have a strong propensity to expel much of the infalling matter as a wind or jet. I briefly review some of the ways in which this can happen, and what we can learn from it.

The roles of partial covering and reflection in the X-ray spectra of NLS1

L. C. Gallo, Th. Boller

MPE

Spectral curvature in the 2-10 keV range and/or sharp spectral drops above 7 keV have been revealed in a number of Narrow-line Seyfert 1 galaxies (NLS1). Two competing models have evolved: (1) partial covering of the intrinsic spectrum by a dense, patchy absorber, or (2) modification of the reflection and power-law components by general relativistic effects. I will focus on two XMM-Newton observations of the NLS1 1H 0707-495. During the two observations the object appeared and behaved quite differently. It is also known that between the two XMM-Newton observations, 1H 0707-495 underwent a dramatic flux change by at least a factor of ten. A comparison of the models and their application to all of the 1H 0707-495 observations will be discussed in detail.

On the origin of the BL Lac phenomenon

M. Whiting

University of New South Wales

The BL Lacertae objects, or BL Lacs, are considered among the most extreme classes of AGN, with multi-wavelength continua dominated by non-thermal emission from a relativistic jet. The origin of the BL Lac phenomenon, and the exact nature of their relationship to other AGN such as quasars is still the subject of much debate. We present recent observations and modelling that challenge some common interpretations of BL Lacs. We find that the dominant factor in a source being called a BL Lac is the intrinsic lack of flux from the broad-line region – likely connected with a weak accretion disc – rather than an overwhelmingly powerful jet. In explaining the origin of the BL Lac phenomenon, we find that the properties of Black Hole X-ray Binaries (BHXRBs) provide a useful model. In these objects, the ejection of jet components is observed to coincide with a depletion of the disc emission – a good analogy to the behaviour of BL Lacs. We discuss how a BHXRB-like model can be applied to explain the observed properties of BL Lacs.

Gamma-ray blazars with UV bumps

M. Sikora

Copernicus Astronomical Center, Warsaw

One of main ingredients of the blazar phenomenon is the highly polarized and variable optical-UV continuum.This radiation, synchrotron in nature, is produced by sub-parsec relativistic jets, and Doppler boosted into the direction of the observer; it dominates the thermal radiation from the accretion flow. Synchrotron emission is often accompanied by production of strong gamma-rays. In blazars hosted by quasars, during outbursts, the gamma-ray to synchrotron luminosity ratio reaches values up to 10-100. Such strong gamma-ray fluxes are believed to be produced by Comptonization of radiation from the broad emission line region. This radiation is collimated even more strongly than the synchrotron emission (by the 6th power of the Doppler factor instead of the 4th) and, therefore, its domination is expected to drop with the increase of the angle of view away from the jet axis. Surprisingly, there is a sub-class of gamma-ray blazars with exceptionally prominent gamma-ray components, but at the same time having the optical-UV radiation dominated by the thermal component. We review properties of these objects and investigate their origin. In particular, we explore the possibility of production of gamma-rays by Comptonization of external IR radiation. An important step towards verification and refinement of that model will be the future multi-wavelength campaigns for γ-ray blazars with UV bumps: such objects are particularly suitable for studies of the structure and physics of parsec-scale jets and their environment.

Variable Emission from SgrA*

A. Eckart, R. Schoedel

Univ. of Cologne

We report on recent simultaneous near-infrared/X-ray observations of the SgrA* counterpart which is associated with the massive 3 to 4 million solar mass black hole at the center of the Milky Way. We concentrate on a flare that was detected in the X-domain with an excess 2 - 8 keV luminosity of about 6×10^{33} erg/s. A fading flare of Sgr A* with >2 times the interim-quiescent flux was also detected at the beginning of the NIR observations, that overlapped with the fading part of the X-ray flare. Compared to 8-9 hours before the NIR/X-ray flare we detected a marginally significant increase in the millimeter flux density of Sgr A* during measurements about 7-9 hours afterwards. We find that the flaring state can be conveniently explained with a synchrotron

self-Compton model involving up-scattered sub-millimeter photons from a compact source component, possibly with modest bulk relativistic motion.

Stellar Dynamcis near Sgr A* and Possible Young Stars in the IRS 13 Complex

R. Schödel, A. Eckart, N. Mouawad

Universität zu Köln

The non-thermal radio, X-ray, and infrared source Sagittarius A* at the center of the Milky Way is the nearest and strongest case for a supermassive black hole. High-resolution near-infrared observations allow us to probe the dense nuclear stellar cluster. We have analyzed the trajectories and orbits of stars at distances less than 50 mpc from Sgr A* in terms of Keplerian and non-Keplerian orbits. They show that a dark mass of about 3.6 million solar masses is coincident with the position of Sgr A* and concentrated in a volume with a radius of less than one light day. From these observations, we can exclude a dense, dark cluster of astrophysical objects as well as a neutrino ball, leaving a black hole as the only plausible explanation. Surprisingly, we find some evidence for radial anisotropy of the stellar velocities in the cusp around the black hole. From an analysis of the best measured orbit of the star S2 in terms of non-Keplerian motion we can set an upper limit to the mass in the stellar cusp of about 0.4 million solar masses, or 10% of the mass of Sgr A*. We also report on stars with a strong infrared excess just north of the IRS 13 cluster. The reddening of these stars might be due to shocked gas in the mini-spiral. Another, very intriguing possibility is that these stars are actually recently formed stars.

Similarities and scaling laws for AGNs and X-ray binaries *(review)*

S. Corbel

Univ. Paris 7 & CEA Saclay

Stellar mass black holes in X-ray binaries (XRBs) share a growing number of similarities with the scale up version in AGNs. This was first recognized with the radio emission that is usually related to relativistic outflows (compact jets and/or discrete ejections). However, a strong correlation between radio and X-ray luminosities in XRBs has recently been found and this raised the possibility that part of the X-ray emission may originate from the jets directly. Inclusion of the mass of the black hole in this picture resulted in the definition of a "fundamental plane of black activity", that may shed light on the emission processes around stellar and supermassive (and also possibly the so-called ULX) black holes. In addition, large scale radio and X-ray jets are now also found in a larger number of XRBs. These lobes are likely due to the interaction of relativistic plasma with the ISM. This mimics the behaviour that is observed on larger scale in AGNs. In this review, I will summarize the observational similarities between these populations of black holes, with special emphasis on the role that jets could play at high energy.

The radio/X-ray correlation and the unification of low power black holes

E. Koerding[1], **H. Falcke**[1,2]

1 – MPIfR, Bonn; 2 – ASTRON, Dwingeloo

In this talk we present a symbiotic disk/jet model for active galactic nuclei (AGN) and black hole X-ray binaries. Scale invariance and energy conservation are used to derive analytical scaling laws for the emission of a jet and allow us to identify the main parameters of the system: the mass of the central black hole and the accretion rate. The developed model can be used to argue for a unifying view of all weakly accreting black holes: a unification

of XRBs and AGN. I classify the zoo of AGN in jet and disk dominated sources and test the unification scheme of weakly accreting sources by establishing a universal radio/X-ray correlation for XRBs and AGN. The now established correlation can be used as a tool to diagnose yet unknown kinds of accreting black holes like the ultra-luminous X-ray sources.

Session III: Outflows from AGN

Relativistic Outflows in AGN *(review)*

Max Camenzind

LSW Königstuhl, Heidelberg

A review is given on recent progress in the theory of relativistic jet production in AGN and simmilar sources. The current popular model for launching, accelerating and collimating astrophysical jets is based on magnetohydrodynamics (MHD). AGN jets are most probably powered by energy extracted from either an accretion disk or a rotating Black Hole. A strong electromagnetic field in the central engine, coupled with differential rotation, serves to convert rotational energy into kinetic energy of outflows. In the last few years, we made some progress in understanding accretion processes for rotating Black Holes: standard disks are truncated at some radius depending on the accretion rate so that disk outflows are driven away by the hot inner disk. Slow outflows are the norm when the magnetorotational instability is at work in the weak field limit. In order to achieve Lorentz bulk factors of about 10, strong large-scale magnetic fields must thread the Black Hole and its environment. The production of relativistic ouflows is then completely understood within stationary MHD models. It is however not yet possible to test these scenarios with fully time-dependent relativistic MHD simulations. Some special cases, such as the force-free limit (so-called Poynting flux jets) have been investigated in the last years. In general, the jet plasma not only consists of magnetic fields, but also of thermal ions and electrons. In the collimated region, the electrons are boosted up to a non-thermal distribution, which is the basis of all observations. This requires the development of a two-component model for relativistic MHD jets which is one of the big challenges for the future.

Highly variable apparent speed of 3C 279

S. Jorstad[1,2] & A. Marscher[1]

1 – IAR, Boston University, USA; 2 – Sobolev Astronomical Inst., St. Petersburg State Univ., Russia

Bimonthly monitoring of the innermost jet in the quasar 3C 279 with the VLBA at 43 GHz from 1998 to 2001 in combination with previous observations, reveal an increase in apparent speed from $5c$ to $17c$ and a change in projected direction of the jet by $\sim 20^\circ$ (Jorstad et al. 2004). We will report new results of the parsec jet behavior from monthly monitoring of the quasar with the VLBA from 2001 to 2004. The radio observations are accompanied by semi-weekly X-ray measurements with the Rossi X-ray Timing Explorer. A connection between X-ray variability and change of the radio jet parameters will be discussed.

Simulations of parsec-scale relativistic jet in 3C273

M. Perucho[1], A.P. Lobanov[2] and J.M. Marti[1]

(1) – Universitat de Valncia, Spain; (2) – MPIfR, Bonn, Germany

We present 2D and 3D hydrodynamical simulations on the relativistic jet in 3C273, in comparison to previous linear perturbation analysis of Kelvin-Helmholtz instability developing in the jet. Our aim is to assess advantages and limitations of both analytical and numerical approaches and to identify spatial and temporal scales on which the linear regime of Kelvin-Helmholtz instability can be applied in studies of morphology and kinematics of parsec-scale jets.

Role of large scale magnetic fields in AGN jets

Maxim Lyutikov[1], Vladimir Pariev[2], Denise Gabuzda[3]

1 – UBC, KIPAC; 2 – University of Rochester; 3 – University College Cork

We consider the polarization properties of optically thin synchrotron radiation emitted by relativistically moving electron–positron jets carrying large-scale helical magnetic fields. In our model, the jet is cylindrical, and the emitting plasma moves parallel to the jet axis with a characteristic Lorentz factor Γ. We draw attention to the strong influence that the bulk relativistic motion of the emitting relativistic particles has on the observed polarization. We conclude that large-scale magnetic fields can explain the salient polarization properties of parsec-scale AGN jets. Since the typical degrees of polarization are $\leq 15\%$, the emitting parts of the jets must have comparable rest-frame toroidal and poloidal fields. In this case, most relativistic jets are strongly dominated by the toroidal magnetic field component in the observer's frame, $B_\phi/B_z \sim \Gamma$. We also discuss the possibility that relativistic AGN jets may be electromagnetically (Poynting flux) dominated. In this case, dissipation of the toroidal magnetic field (and not fluid shocks) may be responsible for particle acceleration.

Using the CMB to probe the matter content of extended quasar jets.

M. Georganopoulos[1,2], E.S. Perlman[1], D. Kazanas[1], F.W. Stecker[2]

1 – JCA/UMBC, Baltimore; 2 – NASA/GSFC, Greenbelt

There are some well known superluminal quasars (e.g. 3C 273, PKS 0637-752, 0827+243) whose jets emit little radiation up to 5-10 arcseconds from the core and then brighten up substantially in radio, optical, and X-ray energies. We argue that the radiating leptons in the second, active part of the jet are transported practically cold through the first, quiescent part, and we use this to estimate the minimum anticipated IR bulk Compton scattering off the cosmic microwave background. Observing this component with Spitzer will actually measure the large scale jet power carried by leptons. This can be used to constrain the hadronic jet power and the injection efficiency of lepton acceleration.

Very long-wave electromagnetic radiation from jets

G.S.Bisnovatyi-Kogan

Space Research Institute, Moscow

Exact solution is obtained for electromagnetic field around a conducting cylinder of infinite length and finite radius, with a periodical axial electrical current, for wave length much larger than the radius of the cylinder. The solution describes simultaneously the fields in the near zone close to the cylinder, and transition to the wave zone. Proper long-wave oscillations of such cylinder are studied. The electromagnetic energy flux from the cylinder is calculated. These solutions could be applied for description of the electromagnetic field around extragalactic jets from active galactic nuclei and quasars and particle acceleration inside jets.

A Multiband Approach to AGN: Radioscopy & Radio Astronomy

M. Kadler[1], E. Ros[1], J. Kerp[2], J.A. Zensus[1]

1 – MPIfR, Bonn; 2 – RAIUB, Bonn

Only in radio-loud active galactic nuclei (AGN) the production, collimation, and acceleration of powerful relativistic jets takes place. Considering that the fundamental difference between radio-quiet and radio-loud AGN is related with the properties of their accretion-flows, it is essential to establish the characteristic differences between both classes at X-rays. Here we present results from a systematic X-ray spectral survey of core-dominated radio-loud AGN. Our sample is based on the VLBA 2cm Survey, a longterm Very-Long-Baseline Interferometry (VLBI) program to study the outflows in extragalactic radio jets. We investigate the dependence of X-ray spectral characteristics on the radio-jet properties on parsec scales. In particular, we will discuss the challenging opportunity to identify the actual trigger of jet formation from combined VLBI and X-ray monitoring observations of core-dominated radio-loud AGN with relativistically broadened iron lines. This hybrid method yields direct insights into the coupling between mass-accretion and jet-formation as demonstrated by a direct accretion-ejection event observation in the active galactic nucleus of NGC1052.

Line-driven winds near black holes

A.V. Dorodnitsyn

Space Research Institute, Moscow

We propose a general physical mechanism which could contribute to the formation of fast line-driven outflows at the vicinity of strong gravitational field sources. We argue that the gradient of the gravitational potential plays the same role as the velocity gradient plays in the standard Sobolev approximation. Both the Doppler effect and gravitational redshifting are taken into account in the Sobolev approximation. The radiation force becomes a function of the local velocity gradient and the gradient of the gravitational potential. The derived equation of motion has a critical point that is different from that of Castor, Abbott and Klein (CAK). A solution, which is continuous through the singular point, is obtained numerically. A comparison with a standard theory theory is presented. It is shown that the developed theory predicts terminal velocities which are greater than those obtained from the CAK theory. The applications of the developed theory to AGN are discussed. Dorodnitsyn, A.V. 2003, MNRAS 339, 569576 Key words: hydrodynamics radiation mechanisms: general quasars: general.

Session IV: AGN across the Universe

AGN and galaxy formation/co-evolution *(review)*

Pierre Cox

Institut d'Astrophysique Spatiale Universite de Paris-Sud Orsay, France

I will review current studies of the dust and molecular gas content of high-redshift radio-quiet quasars. The aim of these observations is to derive the properties of the starburst activity in the host galaxy associated with the QSO and to compare it with the activity of the (super)massive central black hole. The results will be compared with what is known in the local universe (in particular, the relation between the mass of the black hole and the stellar velocity dispersion in the bulge) and with theoretical expectations.

Supermassive black holes in AGN *(review)*

David Merritt

Rochester Institute of Technology

(not available)

EXOs: A Population of Dusty AGN in the Early Universe

Anton M. Koekemoer

Space Telescope Science Institute

Extreme X-ray / Optical sources ("EXO"s) are a recently identified population of sources detected in deep XMM and CHANDRA surveys but with no strong detections of either the AGN or the host galaxies in deep optical imaging, thereby placing them at the extreme end of the Fx/Fopt plane with values about 100 times above typical AGN. The first SPITZER observations of these sources have provided clear detections of all of them, with SEDs indicative of highly reddened and underluminous galaxies at redshifts in the range 3 - 6 or above. The reddening is likely due to dust from intense star-formation that may also be linked to increased accretion onto the central black hole, hence these objects provide a unique probe of the relationship between black holes and galaxy growth in the early universe.

Multiwavelength Number Counts of AGN in the GOODS Fields

E. Treister, C.M. Urry and others

Yale University/Universidad de Chile

We model the X-ray, optical, and far-infrared flux distributions of AGN in the GOODS fields, starting from hard X-ray luminosity functions and spectral energy distributions appropriate to the unified scheme for AGN. The deep optical counts measured from HST ACS images can be well explained by a unified scheme that postulates roughly 3 times as many obscured as unobscured AGN. This scenario is consistent with the observed spectroscopic and photometric redshift distributions of the GOODS AGN once selection effects are considered. The previously reported discrepancy between observed spectroscopic redshift distributions and the predictions of population synthesis models for the X-ray background (which include a similarly large number of obscured AGN)

is explained by bias against the most heavily obscured AGN in both X-ray surveys and optical spectroscopic samples. We present the model predictions for the number counts of AGN in the Spitzer MIPS 24 micron and IRAC 3.6-8 micron bands. The GOODS Spitzer observations will verify whether large numbers of obscured AGN are indeed present in the early Universe; these will be very bright far-infrared sources, including some, missed by X-ray observations, that look like ultraluminous infrared galaxies.

Cores and jets as seen (and sometimes - not seen) at radio and X-ray domains in extremely high redshift quasars

L.I.Gurvits[1], S. Frey[2], A.P. Lobanov[3], D.A. Schwartz[4]

1 – JIVE, Dwingeloo; 2 – FÖMI, Budapest; 3 – MPIfR, Bonn; 4 – CfA, Cambridge

The number of radio loud quasars at high redshifts (z ¿ 4) has grown dramatically over the last several years. We report preliminary results of recent studies of compact (kiloparsecs to parsecs) radio structures in a sample of z¿4 quasars. We emphasize discovery of an unusually prominent core-jet radio structure in the quasar 1715+2145 at z=4.01. Its very pronounced jet traceable with VLBI up to the distance from the core of about 90 mas points approximately at the strong optically unidentified object some 60 arcsec apart which is a strong X-ray emitter. No low-brightness emission has been detected at radio and X-rays between the quasar and the unidentified object. Indirect arguments against physical connection between the two objects are supplied by ad-hoc optical observations. We also discuss surprisingly similar two-object radio morphology found in the most distant radio-detected quasar SDSS 0836+0054 at z=5.82 with the separation between the two objects of about 10 arcsec.

Gamma-Ray Probe of the Dense QSO Environment

A.F. Iyudin[1], V. Burwitz[1], J. Greiner[1], O. Reimer[2], A. Reimer[2]

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Gamma-Ray Probe of the Dense QSO Environment A.F. Iyudin (Max-Planck-Institut fuer extraterrestrische Physik, Postfach 1312, 85741 Garching, Germany; and Moscow State University, Skobeltsyn Institute of Nuclear Physics, Vorob'evy Gory, 119992 Moscow, Russia) V. Burwitz, J. Greiner (Max-Planck-Institut fuer extratyerrestrische Physik, Postfach 1312, 85741 Garching, Germany) and O. Reimer, A. Reimer (Institut fuer Theoretische Physik, Lehrstuhl IV: Weltraum- und Astrophysik, Ruhr-Universitaet Bochum, 44780 Bochum, Germany) Abstract We expand on the recently reported detections of the gamma-ray absorption along the line of sight toward gamma-ray bright quasars (QSOs), like 3C273, 3C279, PKS0528+134 and BL Lac. We propose to use this novel gamma-ray absorption method to study the dense environments of QSOs, and of their respective host galaxies.

Properties of the absorbers that were detected are discussed in the context of the QSO and the host galaxy co-evolution.

IR emission from the dusty veil around AGN

Thomas Beckert

MPIfR

Based on a model for a clumpy and dusty torus surrounding supermassive black holes we discuss the infrared emission of AGN. Both dynamical arguments and the weakness of spectral features in the infrared suggest that dust in the torus is organized in distinct clouds. The optical depth of individual clouds is so large that the clumpiness of the torus is important for the shape of the SED and the appearance of AGN in high resolution speckle imaging and interferometric measurements in the infrared. The underlying dynamical model requires mass accretion rates in the torus on pc-scales above the Eddington limit for the black hole. Our scenario, which includes strong outflows along the symmetry axis and feeding of the central accretion disk together with the torus model, will be tested in nearby sources like NGC 1068.

Mid-Infrared Selection of Obscured AGN

Mark Lacy

California Institute of Technology

Using data from the Spitzer First Look Survey, the Sloan Digital Sky Survey, and archival ISO spectra, we have developed a technique for identifying AGN based soley on their mid-infrared colors. In particular, this allows us to find canditate AGN whose optical/UV and X-ray emission is hidden by obscuring columns of dust and gas. We present the results of follow-up of a sample of AGN selected in this manner which suggests that around 50

Comparing isolated active and non-active galaxies

I. Marquez and DEGAS Consortium

IAA, Granada

In order to understand the fueling mechanism that powers AGN, a large effort was made by the DEGAS (Dynamics and nuclear Engine of GAlaxies of Spiral type) consortium to collect the necessary observational material. We defined a sample of 17 isolated AGN and a control sample of 16 normal spirals with the same properties (luminosity and redshift distribution, morphology, percentage of bars) than the AGN sample. Based on the analysis of their NIR images (Márquez et al. 1999, 2000), on long slit spectroscopy at various slit position angles in the Halpha emission and Calcium triplet absorption lines (Pérez et al. 2000, Márquez et al. 2003, 2004), we conclude that: - the morphology and large scale kinematics of AGN hosts and normal spirals are equivalent; - the differences claimed to be related to the mechanisms driving AGN activity may only be found in details related to circumnuclear regions still unresolved by our observations; - the presence of drops in the velocity dispersions seems related to the existence of a central elongated structure, probably an inner disk, where the CaT equivalent width also reaches a maximum. We now propose to study a much larger sample of 83 AGN and normal host spirals with better spatial and spectral resolutions to see whether inner disks, velocity drops and young stellar populations are related phenomena, as suggested by present day numerical simulations. Optical and NIR HST images of all these galaxies have already been analyzed, and we now intend to observe them spectroscopically in the CaT lines.

Posters

I. AGN across the Spectral Bands

1

Photoionised Hβ emission in NGC 5548: It Breathes!

Keith Horne and Edward M. Cackett

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Emission line regions in active galactic nuclei and other photoionisied nebulae should become larger in size when the ionizing luminosity increases. We detect this 'breathing' effect for the Hβ emission in NGC 5548 by using Hβ and optical continuum lightcurves from the 13-year 1989-2001 AGN Watch monitoring campaign. To search for breathing, we use the MEMECHO reverberation mapping code to fit the observed lightcurves in detail. Our model assumes that optical continuum variations track the ionising radiation, and that the Hβ variations respond with time delays, τ, due to light travel time. By fitting the data using a delay map, $\Psi(\tau, C)$, that is allowed to change with continuum flux, C, we find that the strength of the Hβ response decreases and the median time delay increases with ionising luminosity. Both effects are prediced for ionisation-bounded nebulae, and are now observed.

2

Profile variability of the H-alpha and H-beta broad emission lines in NGC5548

V. H. Chavushyan, A. I. Shapovalova, V. T. Doroshenko, et al.

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Between 1996 and 2002, we have carried out a spectral monitoring program for the Seyfert galaxy NGC 5548. High quality spectra (S/N¿50), covering the spectral range (4000-7500)AA were obtained with the 6 m and 1 m telescopes of SAO (Russia) and with the 2.1 m telescope GHO (Mexico). We found that both the flux in the lines and the continuum gradually decreased, reaching minimum values during May-June 2002. The mean, rms, and the averaged over years, observed and difference line profiles of H-alpha and H-beta reveal the double peaked structure at the radial velocity +-1000km/s. The relative intensity of these peaks changes with time. During 1996, the red peak was the brightest, while in 1998 - 2002, the blue peak became the brighter one. In 2000-2002 a distinct third peak appeared in the red wing of H-alpha and H-beta line profiles. The radial velocity of this feature decreased between 2000 and 2002 from +2500 km/s to +2000 km/s. The fluxes of the various parts of the line profiles are well correlated with each other and also with the continuum flux. Shape changes of the different parts of the broad line are not correlated with continuum variations and, apparently, are not related to reverberation effects. Changes of the integral Balmer decrement are, on average, anticorrelated with the continuum flux variations. This is probably due to an increasing role of collisional excitation as the ionizing flux decreases. Our results favor the formation of the broad Balmer lines in a turbulent accretion disc with large and moving "optically thick" inhomogeneities, capable of reprocessing the central source continuum.

3

The UV spectral properties of radio loud and radio quit AGNs: The ratio of NV/Ly-alpha and CIV1550/L

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We present a study on properties of ultraviolet spectra of the low red-shifted (with red-shift ¡0.05) sample of radio-loud and radio-quite active galactic nuclei (AGNs). The sample of galaxies was observed with the Hubble Space Telescope. We measured the ratios CIV1550/Ly-alpha and NV/Ly-alpha in order to see the similarities and differences in the UV emitting line region of radio-loud and radio-quite AGNs. Here we present our preliminary results.

4

Optical Photometry of X-ay Selected BL Lacetae Objects

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We present optical R band photometry for nine X-ray Einstein Slew Survey Sample BL Lacertae objects: 1ES 0323+022, 1ES 0502+675, 1ES 0647+250, 1ES 0806+524, 1ES 1028+511, 1ES 1959+650 and 1ES 2344+514. Two blazars 1ES 0229+200 and 1ES 0927+500 didn't show any detectable variability. All they have been observed with ST-6 CCD camera attached to Newtonian focus of the 70-cm meniscus telescope. These data provide optical information on sources that have been rarely observed in the optical band. Variability on long time scales within one magnitude in R band was detected for all of the observed objects. Largest variation was observed for 1ES 0502+675 and equals to 1.07 mag in R band.

5

Behaviour of BL Lacertae During 1997-2002

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Behaviour of BL Lacertae During 1997-2003: Long-Term, Intraday and Intrahour Variability Maria G. Nikolashvili Abastumani Observatory, 383762 Abastumani, Georgia We present the results of optical observations of BL Lacertae from August 1997 to Dec 2003 carried out with ST-6 CCD Camera attached to the Newtonian focus of the 70-cm meniscus telescope of Abastumani Observatory. The long-term, intraday and intahour variabilities of BL Lacertae were studied on the bases of 317 and 259 nights, respectively. The variability pattern showed by BL Lacertae is very complex. The maximum amplitude of the long-term variability in B band equals to 3.0 mag (rms=0.03). The variation in V and R bands are within 2.71 (0.02) and 2.53 (0.01), respectively. This means that variations are larger at shorter wavelength or the object become bluer in the active phase. It were also demonstrated that BL Lacertae shows intraday variability within 0.30 (0.02), while intrahour variability within 0.10 (0.01) magnitudes.

6

Multifrequency studies of the TeV blazar PKS 2155-304

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TeV γ-ray observations of several blazars with the previous generation of imaging atmospheric Cherenkov telescope instruments have revealed interesting insights into jet physics, in regions very close to the central black hole. With H.E.S.S., the first of the new generation instruments, the available sensitivity has been significantly increased, while the energy threshold was lowered to 100 GeV. H.E.S.S. consists of four 12 m class Cherenkov telesopes running in coincidence for the stereoscopic detection of γ-ray induced air showers. The array is located in Namibia and became fully operational with the beginning of 2004. A major share of the H.E.S.S. observing program is devoted to AGN physics. One of the first extragalactic targets which H.E.S.S. observed was PKS 2155-304, a high-peaked BLLac from which TeV γ-ray emission had already been claimed by the Durham group. The H.E.S.S. observations in 2002 and '03 (using subsets of the array during its comissioning phase) confirmed that PKS 2155-304 is indeed a TeV γ-ray emitter. Moreover, the continuous detection of the source demonstrated that with the sensitivity of the new instruments not only flaring states but also quiescent stages of TeV blazars can now be investigated in detail. Since then, we have studied PKS 2155-304 using not only H.E.S.S. alone, but also in multifrequency campaigns employing H.E.S.S., the X-ray satellite RXTE, and ground based optical and radio telescopes. The obtained broad band spectral energy distribution as well as flux correlation studies are used for the modeling of the emitting particles in the jet. Another important aspect is the modification of the measured TeV spectra of blazars by the interaction of TeV photons with the cosmic infrared background. PKS 2155-304 (z=0.117) is the second most blazar detected in TeV γ-rays so far, and significant absorption signatures in its spectrum are expected.

II. AGN across the Luminosity Range

7

Accretion Disks around Black Holes with Optical Depth Transition and Advection

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We consider the effects of advection and radial gradients of pressure and radial drift velocity on the structure of accretion disks around black holes. We concentrated our efforts on highly viscous disk with large accretion rate. Contrary to disk models neglecting advection,we find that continuous solutions extending from the outer disk regions to the inner edge exist for all accretion rates we have considered. We show that the sonic point moves outward with increasing accretion rate, and that in the innermost disk region advection acts as a heating process that may even dominate over dissipative heating. Despite the importance of advection on it's structure, the disk remains geometrically thin. Global solutions of advective accretion disks, which describes continuosly the transition between optically thick and optically thin disk regions are constructed and analyzed.

8

Destroying degeneracy: Spannign the luminosity range for radio quiet quasars at $z \geq 4$

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The existing sample of quasars with X-ray data suffer from selection such that luminosity is artificially correlated with redshift. In our Chandra+XMM survey of radio-quiet $z \geq 4$ quasars, we found that α_{ox} and Γ_x are strong functions of redshift but also weak functions of luminosity, whereas other studies suggest that these X-ray parameters depend most strongly on L. So far, only the brightest $z > 4$ quasars have been targeted with Chandra, to keep exposure time short; this strategy only strengthens the $L - z$ correlation. To remedy this situation, we have observed 7 faint, radio-quiet quasars at $z \geq 4$. We study how α_{ox} and Γ_x depend on L and z, as well as investigate how blackhole mass and accretion rate depend on L and z, using new models for accretion disks with hot coronae.

9

An inverse method for stellar population synthesis. - Application to AGN

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I will present a new inverse method for stellar population synthesis in unresolved galaxies. This method provides the unique solution that fits at best a composite object spectrum using a database of stellar spectra. It provides as well an estimation of the error around the solution giving thus a confidence level to the result. The reddening in the optical spectrum due to the presence of dust, the dust emission in the IR and the velocity dispersion of stars are also modelled. Finally, the method will be applied to the spectra of AGNs, in particular to Seyfert galaxies, to understand the relation between the starburst phenomenon and the presence of an active nucleus.

10

X-Ray Nature of the LINER Nuclear Sources.

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A strong debate is still going on about the origin of the energy source in LINERs. Two alternatives have been explored: low luminosity AGN or thermal origin from the evoluction of massive star clusters in their centers. We have investigated all LINERs with X-ray data from the catalogue by Carrillo et al. (1999). This amounts to 60 out of 476 LINERs for which ACIS-S imaging data are available. In most galaxies a nuclear compact source has been detected in the hard (2-8 kev) spectrum and they show a rather irregular morpholgy embedded in diffuse X-ray emission for lower energies (0.3-2 kev). In this work we report the spectral analysis of the nuclear source. Color-color diagrams allow us to determine the dominant mechanism in them. Synthetic colors have been computed for a power-law, thermal emission (Raymond-Smith model) and a combination of both. The rather preliminary results suggest a non thermal nature in most of the LINER galaxies observed.

11

Starburst-AGN Connections: Clues from Poststarburst Broad Line AGN in the SDSS DR2

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A sample of 74 poststarburst broad line AGN are selected from the spectroscopic dataset of the Sloan Digital Sky Survey Data Release 2 (SDSS DR2) based on two criteria, 1) the Eqivalent Width of $H\delta$ absorption line, $EW(H\delta) \geq 5$ Å; and 2) at least one broad emission line detected. Because in these so-called "Q+A" objects we are witnessing the field pickup of significant change in the star formation histories of the host galaxies and in the meantime viewing the activity of the nuclei directly, the present sample suits extraordinarily to address the important yet long debated issue concerning the physical link between starburst and AGN phenomena. We find that more than half of the Q+As have broad emission line width (Full Width at Half Maximum, FWHM) less than 2000 $km\ s^{-1}$, fulfilling the formal line width criterion for Narrow Line Seyfert 1 galaxies (NLS1s). Strong optical FeII emission is detected in objects with prominent broad component of $H\beta$, which is also typical of NLS1s. The central black hole mass was estimated grounded on the broad line width-luminosity-mass scaling relation and the empirical $M_{BH} - \sigma_*$ relationship. We find that for most Q+As, the deduced mass accretion rate, $\dot{m}$, is close to or larger than Eddington rate, $\dot{m}_{Edd}$. If these engorging objects, especially the NLS1s are indeed AGN in their early evolution stage, this result strongly suggests that the nuclear activity be driven by starburst with a time delay of $\sim$ a few hundred Myr.

12

Multiband observations of the microquasar LSI +61 303

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Multiband observations at Gamma-ray, X-ray, optical and radio-wavelength of the microquasar LS I +61°303 are discussed in the context of the modified accretion model for a high eccentric orbit.

III. Outflows from AGN

13

The youngest radio sources

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We present high dynamic range VLBA images of very young radio sources ($< 10^3$ yr) in which two minilobes and the very weak core have been detected. We summarise the properites of this class of objects where the radio emission has just started.

14

What Types of Jets Does Nature Make? A New Population of Blazars

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We have recently discovered a population of strong-lined blazars with jet synchrotron emission peaks in the UV/X-ray regime. So far, only radio quasars with lower synchrotron energy cut-offs (and so X-rays dominated by inverse Compton emission) were known. Our discovery challenges theories which posit that particle cooling by an external radiation field, such as the one produced by, e.g., an accretion disk, controls the jet synchrotron spectral cut-off. Here we present the first VLA maps and preliminary results from XMM spectroscopy of these new class of blazars and discuss their relation to the high-energy peaked BL Lacertae objects.

15

A supermassive binary black hole in the quasar 3C345

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The binary black hole model, applied to the quasar 3C 345, explains the observed variations of radio and optical emission from the quasar, and reproduces the structural variations observed in the parsec-scale jet of this object. The binary system in 3C 345 is described by two equal-mass black holes with masses of $\approx 7.1 \times 10^8 \mathrm{M}_{solar}$ separated by ≈ 0.33 pc and orbiting with a period ~ 480 yr. The orbital motion induces a precession of an accretion disk around the primary black hole, with a period of ≈ 2570 yr. The jet plasma is described by a magnetized, relativistic electron-positron beam propagating inside a wider and slower electron-proton jet. The combination of Alfvén wave perturbations of the beam, the orbital motion of the binary system and the precession of the accretion disk reproduces the variability of the optical flux and evolution of the radio structure in 3C 345. The timescale of quasi-periodic flaring activity in 3C 345 is consistent with typical disk instability timescales. The present model cannot rule out a small mass orbiter the accretion disk and causing quasi-periodic flares.

IV. AGN across the Universe

16

Recurrent Activity in Radio Galaxies

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One of the outstanding issues concerning extragalactic radio sources is the total duration of their active phase and the possible existence of duty cycles of nuclear activity. A duty cycle can be recognised if there is a mechanism which preserves the information of a past activity sufficiently long time after a new activity has started up. From the study of relic radio galaxies we know that radio lobes could remain visible for relatively long timescale after the central activity switched off. If a new cycle of activity starts before the radio lobes coming from the former activity have faded, we can in principle recognise this by the observations of a young radio source embedded in an old relic structure.

17

Mergers and binary systems of SMBH in the contexts of nuclear activity and galaxy evolution

A.P. Lobanov

Galaxy evolution and nuclear activity in galaxies can be connected with the cosmological evolution of supermassive black holes (SMBH) in the galactic nuclei. Galaxies are expected to merge frequently over the course of their formation and cosmological evolution, leading to the the formation of binary systems of SMBH. Binary SMBH are likely to play a crucial role in formation and evolution of active galactic nuclei (AGN). The dynamic evolution of a binary SMBH may be a key factor affecting a large fraction of the observed properties of AGN and galaxy evolution. In this framework, different classes of AGN can be related in general to 4 different evolutionary stages in a binary SMBH: 1) early merger stage; 2) wide pair stage; 3) close pair stage; and 4) coalescence stage. This scheme will be described in the contribution, in connection with a variety of observational properties that can be explained by the binary SMBH scenario: radio and optical luminosity variations between different classes of AGN, long-term and short-term variability, quasi-periodic nuclear flares, and recurrent formation of relativistic outflows in AGN and their apparent morphology and kinematics.

18

The nature of the mid-IR-faint radio sources from the Spitzer First Look Survey

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Data from the Spitzer Space Telescope (the First Look Survey - FLS) have recently been made public. We have compared the 24 micron images with very deep WSRT 1.4 GHz observations (Morganti et al. 2004), centred on the FLS verification strip (FLSv). Around 2/3 of the radio sources have corresponding 24 micron identifications.

Such a close correspondence is expected, especially at the fainter radio flux density levels, where star forming galaxies are thought to dominate the source counts. Spitzer detects many sources that have no counter-part in the radio. However, a significant fraction of radio sources detected by the WSRT have no mid-IR identification in the FLSv (implying a 24 micron flux density $le 100\,\mu$Jy). The fraction of radio sources without a counterpart in the mid-IR appears to increase with increasing flux density, perhaps indicating that some fraction of the AGN population may be detected more readily at radio than at MIR wavelengths. We present initial results on the nature of the radio sources without Spitzer ids, using data from various multi-waveband instruments, including the publicly available R-band data from the Kitt Peak 4-m telescope.