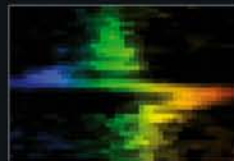
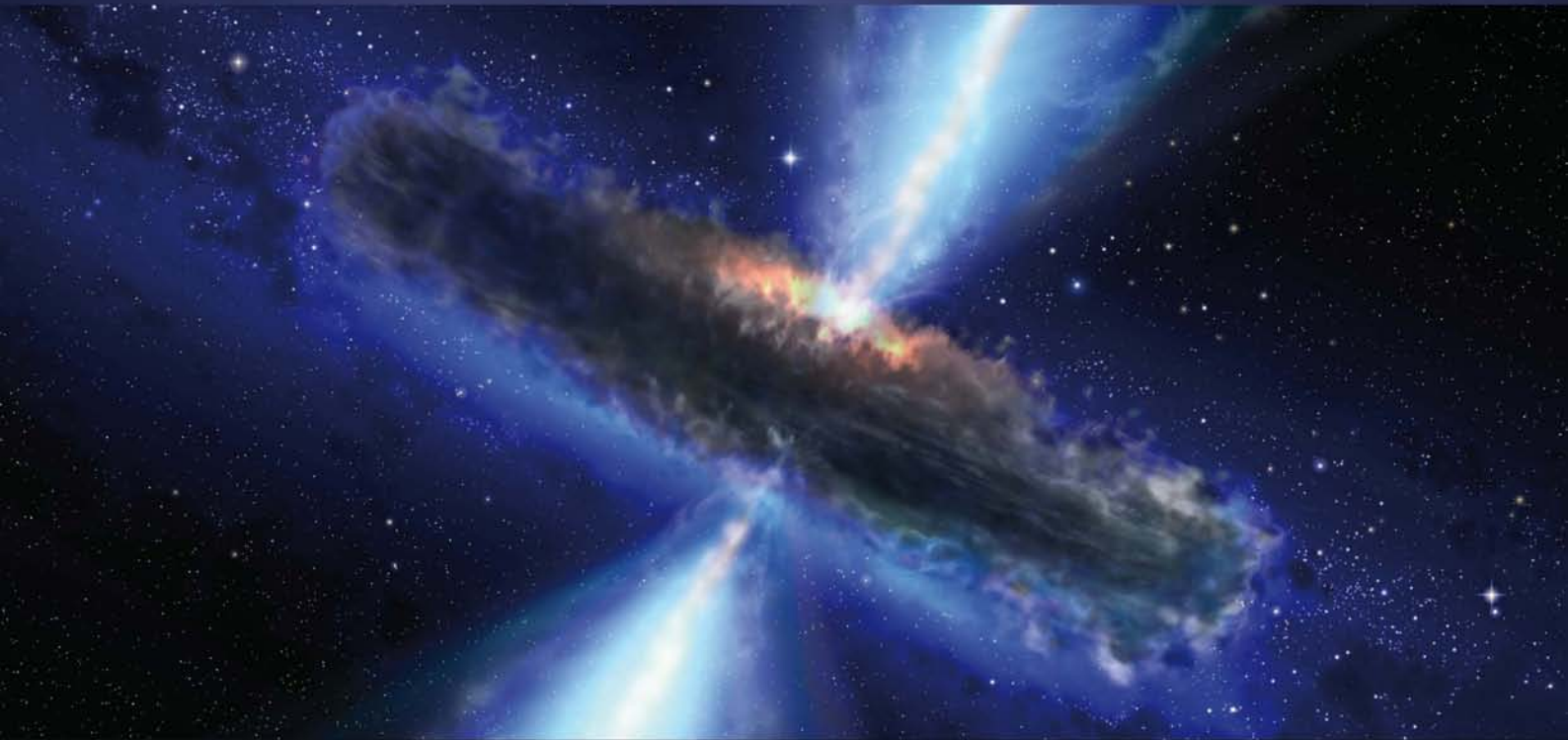


Obscure(d) AGN Across Cosmic Time

an ESO workshop 5th - 8th June 2007



Scientific Topics

Multiwavelength identification of Type 2 AGN: X-ray, optical, mid-IR, submillimeter and radio selection

Structure and origin of obscuration, connection to Type 1 AGN, detailed studies of local AGN

AGN feedback processes: Observations and theory

Host galaxy properties: Star formation, masses, $M-\sigma$ relation

$\text{Ly-}\alpha$ blobs and haloes, extended emission

Large scale environments

Invited Speakers

Dave Alexander
Mitch Begelman
Philip Best
Reinhard Genzel
Günther Hasinger
Tim Heckman
Matt Lehnert
Roberto Maiolino
Raffaella Morganti
Marek Sikora
Daniel Stern
Nadia Zakamska

SOC

Jacqueline Bergeron (IAP)
Carlos De Breuck (ESO, co-Chair)
Wil van Breugel (LLNL/UC Merced)
Robert Fosbury (ST-ECF)
Guinevere Kauffmann (MPA)
Julian Krolik (JHU)
Ari Laor (Technion)
Vincenzo Mainieri (ESO)
Patrick Ogle (SSC)
Steve Rawlings (Oxford)
Daniel Stern (JPL)
Joël Vernet (ESO, co-Chair)
Montserrat Villar-Martín (IAA)

LOC

Pamela Bristow
Carlos De Breuck
Robert Fosbury
Vincenzo Mainieri
Britt Sjöberg
Christina Stoffer
Joël Vernet

5th - 8th June 2007

Kloster Seon
near Chiemsee,
Bavaria, Germany

Abstract Booklet

Obscured AGN Across Cosmic Time

Kloster Seeon, Bavaria

June 4th - 8th, 2007

Session 1: Finding Type-2 AGN

Tuesday 5 June 2007

Identification of AGN in radio surveys

Philip Best

Institute for Astronomy, Royal Observatory Edinburgh

In this talk, I will provide an brief overview of what has been learned about obscured AGN and their evolution from radio surveys. I will summarise results from the major radio surveys over the last four decades, including: the identification of radio sources; unification schemes of radio-loud AGN; the cosmic evolution of the radio source space density and other radio source properties; the Fanaroff-Riley radio morphology dichotomy, and high and low excitation sources; the host galaxies of radio-loud AGN; and radio-loud AGN feedback. I will finish with a quick look forward to the future of radio astronomy.

Identification of AGN in mid-IR survey

Daniel Stern

JPL

Mid-infrared photometry provides a robust technique for identifying active galaxies. While the ultraviolet to near-infrared continuum of normal galaxies is dominated by stellar black body emission and peaks at approximately 1.6 microns, the ultraviolet to mid-infrared continuum of AGN is dominated by a power law. Consequently, with sufficient wavelength baseline, one can easily distinguish AGN from stellar populations. I will review Spitzer Space Telescope mid-infrared colors of active galaxies, which provide remarkably robust separation of such sources from normal galaxies and Galactic stars. These color criteria, typically determined from unobscured AGN samples, imply a much larger population of optically-obscured active galaxies.

The Spitzer-Herschel Active Galaxy Survey

Matt Jarvis

Centre for Astrophysics Research

I will present recent results from our Spitzer survey of a large sample of AGN at $z=1$ which spans 2 decades in optical luminosity, with matched samples of radio-loud quasars and radio galaxies. This sample will also be the subject of a Herschel open time key project proposal to investigate the cold dust component in this benchmark sample of AGN.

Obscured quasars at high redshift

Alejo Martinez-Sansigre

Max-Planck Institut für Astronomie

Obscured AGN have been known for a long time, in the form of Seyfert-2s and radio-galaxies, however, the population of high-redshift, powerful, obscured AGN (type-2 quasars) has remained elusive. The deep X-ray surveys have found many obscured AGN, but only a small number of genuine powerful, high-redshift obscured quasars. Using a combination of mid-infrared and radio data (from Spitzer and the VLA) we have found a successful method of finding for $z > \sim 2$ type-2 quasars. These obscured quasars probably outnumber the unobscured (type-1) quasars by a ratio $\sim 2-3:1$. I will discuss the selection of these objects and what we have learnt from optical spectroscopy and multi-frequency radio observations, and the possibility of quasars obscured by dust in the host galaxy instead of the torus. Finally, I will describe a similar sample in which we find evidence for a significant fraction of quasars which are optically thick to Compton scattering.

Identification of obscured QSOs and properties of their obscuring matter

Mari Polletta

University of California, San Diego

The properties (spectral energy distributions, redshifts and luminosities) of AGN samples selected using infrared, X-ray and radio data, separately, are compared to assess the selection biases of each sample. We show that a mid-infrared selection can efficiently find obscured QSOs at high redshifts. The spectral energy distributions and infrared spectra of the most luminous obscured QSOs discovered so far by such a selection technique are modeled using clumpy torus models. The models indicate that mid-infrared obscuration is not associated with a preferential dust distribution and orientation. In some obscured QSOs, the torus is nearly face-on and absorption in the host must be invoked to explain the observed infrared spectra. We also present a comparison between X-ray absorption and mid-infrared obscuration in QSOs.

Obscured AGN at intermediate and high redshift

Almudena Alonso-Herrero

IEM, CSIC

We will discuss the properties of obscured AGN at cosmological distances. In the first part of the talk we will present the properties of so-called infrared power-law galaxies in the Chandra Deep Field North and South. These galaxies are selected such that their spectral energy distributions in the Spitzer/IRAC bands exhibit the characteristic power-law behavior of luminous AGN. Infrared-power law galaxies are a subset of mid-infrared sources selected via IRAC color-color criteria, and tend to comprise a significant fraction of the Spitzer-detected luminous AGN population at high luminosities and redshifts ($z > 1$). Only about half of them are detected in X-rays (75% at the 3 sigma level). This together with their overall X-ray through mid-infrared properties indicate that a large fraction of the power-law galaxies are heavily obscured. We will also present results on the star formation histories in the host galaxies of optically-dull AGN at intermediate redshifts ($z \sim 0.5-0.8$). These sources have X-ray luminosities characteristic of AGN but no AGN emission lines in their optical spectra. Both dilution by the host galaxy and extinction in the host galaxy may be responsible from hiding their optical AGN emission lines. Since the AGN does not dominate their optical and infrared emission, they offer a unique opportunity to study the star formation histories of their host galaxies. We compare their star formation histories of with those of actively star forming galaxies at similar redshifts.

Identification of AGN in X-ray surveys

Dave Alexander

Durham University

I will discuss the ability of the current deep X-ray surveys to identify AGN activity out to high redshift and review what these surveys have found. I will highlight the limitations of even the deepest X-ray observations in finding Compton-thick AGNs and then present new research that shows that a combination of infrared and X-ray observations provides the potential to identifying even the most extreme Compton-thick AGN and paving the way towards a complete census of AGN activity.

Swift/BAT Complete Hard X-ray Survey of Local AGN

Jack Tueller

NASA/GSFC

The Swift BAT hard x-ray (14-200 keV) survey is the first complete all-sky catalog of hard x-ray detected AGN. At the BAT energies, absorption does not significantly effect the detection of Compton-thin sources and the true luminosity of the AGN can be derived directly from the BAT spectrum. We will discuss the Compton thick objects detected by BAT. The Swift XRT telescope is used to identify BAT survey sources that cannot be identified from catalog searches and to directly measure N_H for sources without previous soft x-ray spectra. Half of the BAT selected AGN have $\log N_H > 22$, which is much lower than predictions derived from using the standard model to fit the X-ray background (ratio 4/1). These results are consistent with similar INTEGRAL surveys over smaller parts of the sky. Most BAT spectra do not show a break below 150 keV, which is also a problem for fitting to the X-ray background. Strong evolution of the average AGN spectrum is required to make the BAT results consistent with fitting the X-ray background as the sum of AGN. As complete samples, the BAT and INTEGRAL samples provide a unique new resource. Unbiased studies of the statistical properties of AGN hosts are now possible with adequate statistics. The AGN detected include many newly discovered bright nearby AGN that are heavily obscured. We will discuss some interesting results from our initial followup studies.

Obscured AGN in the Chandra Deep Field South

Paolo Tozzi

INAF - Osservatorio Astronomico di Trieste

We reconsider the resolved fraction of the hard XRB in the Chandra Deep Field South, taking advantage of the detailed spectral analysis of single sources. In particular, we carefully evaluate the contribution from strongly absorbed AGN, whose detectability is lower with respect to type I AGN at similar flux levels. We find that the fraction of the resolved XRB contributed by AGN is not decreasing at high energies as rapidly as shown in Worsley et al. (2005). We also discuss optical, radio and IR properties of the most obscured, X-ray selected AGN observed in the Chandra Deep Field South. Consequences for the quest for the still missing population of obscured AGN are discussed.

Obscured AGN in Clusters of Galaxies

Paul Martini

The Ohio State University

We have conducted a survey of eight low-redshift clusters of galaxies with Chandra and Magellan and measured an unexpectedly high AGN fraction of five percent, or a factor of five times higher than previous estimates based on visible-wavelength spectroscopy. Although the large X-ray luminosities and flux ratios of these galaxies indicate they are AGN, approximately 90 percent of the 35 AGN in our sample do not show emission-line signatures in visible-wavelength spectra. These AGN are therefore either highly obscured or optically dull. We will discuss the nature of these AGN, their distribution in clusters of galaxies, analogs in the field and at other wavelengths, and implications for both AGN and cluster galaxy evolution.

Identification of AGN in optical surveys

Nadia Zakamska

Institute for Advanced Study, Princeton

I will describe the methods used to select obscured AGN from optical surveys. I will then review multi-wavelength properties of optically selected obscured AGN, specifically focusing on the high luminosity sources and the use of optically selected samples in testing AGN selection methods at other wavelengths. Finally, I will discuss the potential for calculating the space density of obscured AGN using optically selected samples.

Current Searches for AGN at the Highest Redshifts

Anton Koekomoer

Space Telescope Science Institute

The advent of deep and wide multi-wavelength surveys provides unprecedented new opportunities to search for very high redshift active galactic nuclei by constructing samples of sources that are detected at X-ray wavelengths and in the infrared, but completely undetected at optical wavelengths to very deep limits. I will describe current progress on searching for candidate AGN at or beyond redshift 6-7, such as the 'EXO's selected from deep multiband X-ray/HST/IR surveys such as GOODS and similar more recent projects. Together with deep spectroscopy programs, the optical flux limits are combined with IR detections and X-ray fluxes to understand the spectral energy distributions of the sources and help discriminate intermediate-redshift interlopers from the rare number of likely high-redshift candidate sources. The results are used to examine the evolution of the AGN luminosity function at high redshift, with corresponding implications for the co-evolution of galaxies and their central black holes.

X-ray selected obscured AGN in COSMOS: a combined X-ray, optical and infrared view

Marcella Brusa

Max Planck Institut fuer Extraterrestische Physik (MPE)

One of the main goal of the XMM-Newton COSMOS survey is to provide a comprehensive characterization of the multiwavelength properties of AGN selected in the X-rays over a wide range of redshift and luminosities, and eventually, build up the first bolometric selected AGN sample, fulfilling the promise of many years of multi-wavelength studies of quasars. Here we present the results obtained by exploiting the first data available from the XMM-COSMOS program (including ACS morphological information and extensive optical spectroscopy). Our analysis reveals that for $\sim 80\%$ of the counterparts there is a very good agreement between the spectroscopic classification, the morphological parameters as derived from ACS data, and the optical to near infrared colors: the large majority of spectroscopically identified broad line AGN (BL AGN) have a point-like morphology on ACS data, blue optical colors in color-color diagrams, and an X-ray to optical flux ratio typical of optically selected quasars. Conversely, sources classified as narrow line AGN or normal galaxies are on average associated with extended optical sources, have significantly redder optical to near infrared colors and span a larger range of X-ray to optical flux ratios. Our analysis also suggests that the Type 2/Type 1 ratio decreases towards high luminosities, in qualitative agreement with the results from X-ray spectral analysis and the most recent modeling of the X-ray luminosity function evolution. In addition, we present also preliminary results on the mid-infrared (Spitzer/IRAC) properties of our AGN sample, focusing in particular on the obscured AGN population.

**Session 2: The nature and structure of
obscuration**

Wednesday 6 June 2007

The nature and structure of obscuration

Roberto Maiolino

INAF - Osservatorio Astronomico di Roma

I will review our understanding of the structure, location and origin of the obscuring medium in AGNs as inferred from recent observations. I will also discuss the nature of the absorbing medium in terms of gas/dust content and gas/dust properties derived from multiwavelength data, mostly in nearby AGNs. Finally, I will discuss the implications of these findings on the identification and characterization of obscured AGNs at high redshift.

Supporting Optically Thick Obscuration by Infrared Radiation Pressure

Julian Krolik

Johns Hopkins University

Because the opacity per unit mass that dusty interstellar gas presents to mid-infrared photons is 10–30 times as large as the Thomson opacity, it has long been recognized that the radiation from sub-Eddington AGN can produce a force comparable to gravity as it passes through surrounding obscuring matter. In this talk, I will report a new self-consistent solution to both the radiation transfer problem and the equations of hydrostatic equilibrium demonstrating that, subject to certain conditions, light from an AGN can support geometrically thick toroidal obscuration.

Misaligned Fuelling and the Unified Scheme

Andy Lawrence

Royal Observatory Edinburgh

I will briefly review the statistics of different AGN types from samples selected in different ways, and the evidence for any variation with luminosity and redshift. I will describe why torus models, including my own earlier "receding torus" model, don't work. Finally I will present a simple new unified scheme model based on precessing warped discs.

Broad-line heavily obscured AGN at $z \sim 2$

Kate Brand

STScI

We present Keck and Gemini near-IR spectroscopy, Spitzer mid-IR spectroscopy, and HST imaging of a sample of extreme infrared luminous ($L_{IR} \sim 10^{13}$ solar luminosities), optically faint galaxies selected from a 24 micron Spitzer imaging survey of the NDWFS Bootes field. Based on the widths of the emission lines or on line diagnostics, we find that all 10 galaxies harbor luminous AGN. Given their extreme optical-to-mid-IR colors ($R-[24] > 14$), we might expect these sources to be heavily extinguished quasars, and therefore only visible as type II AGN. However, 70% of the sources are type I AGN, exhibiting broad (> 1900 km/s) $H\alpha$ or $H\beta$ emission lines. This suggests that in these cases, the line of sight to the broad-line region are not completely obscured; hence it is unlikely that these AGN are being viewed through the mid-plane of a dusty torus. For 4 of the sources, we constrain the $H\alpha/H\beta$ Balmer decrement and estimate the extinction to be large for both type I and type II AGN, with $A(H\alpha) > 2.4-5$ mag. Since the narrow-line region must be extinguished and the UV continuum emission from the host galaxies is extremely faint, this suggests that much of the obscuration is contributed by dust on large (\sim kpc) scales within the host galaxies. Indeed, our HST imaging reveals that the light is diffuse and extended over large scales. These sources may be examples of 'host-obscured' AGN with space densities comparable or greater than that of optically luminous type I AGN with similar bolometric luminosities.

Unobscured AGN across cosmic time – what radio galaxy populations tell us about accretion modes

Martin Hardcastle

University of Hertfordshire

I will discuss the evidence that an important population of radio-loud active galaxies may completely lack the conventional obscuring torus and accretion disc, and may be powered by accretion from the hot phase of the IGM. If correct, this picture has important implications for the evolution of AGN populations and for the nature of AGN 'feedback' at different cosmic epochs.

Extreme X-ray absorption variability in the Seyfert Galaxy NGC 1365

Guido Risaliti

INAF - Arcetri Observatory

I present a set of Chandra and XMM-Newton observations of the Seyfert Galaxy NGC 1365 showing extreme variability due to absorbing clouds crossing the line of sight: 1) a Chandra monitoring revealed a complete eclipse of the X-ray source in a time as short as two days, during which only the reflected component was visible; 2) a long XMM-Newton observation spectrally resolved the crossing of a thin cloud ($N_H \sim 10^{23} \text{cm}^{-2}$) along the line of sight. These observations provide a direct way to measure the dimensions of the X-ray source, which is estimated to be as small as $\sim 10^{14}$ cm, and of the distance from the center of the circumnuclear absorber, which cannot exceed that of the innermost Broad Line Clouds.

Interferometric observations of the circumnuclear dust in AGN

Konrad Tristram

MPIfr Astronomie

According to unification schemes of AGN, the dust surrounding the supermassive black hole and its accretion disc plays a key role in the diversity of AGN types observed. This dust is expected to reprocess the nuclear light and to emit it in the mid infrared. However, even the largest contemporary single dish telescopes fail to resolve the mid infrared emission and hence to characterise the dust morphology. In order to shed light on the nature of the obscuring material interferometric observations have to be performed.

Here we report on the status of our programme to resolve the mid infrared emission in nearby AGN using the mid infrared interferometric instrument MIDI of the VLTI. In two targets, NGC 1068 and Circinus, our interferometric measurements have resolved the emission well. In both targets we find a clumpy disc-torus configuration which is oriented roughly perpendicular to the ionisation cone and outflow. Furthermore, the dust structures are aligned in the same direction as the water maser discs found in each of the two galaxies. In Centaurus A on the other hand, half of the emission is unresolved. We interpret this unresolved emission as synchrotron radiation from the footpoint of the jet. Several further targets have been observed and we find most of them to be unresolved, highlighting the need for observations with longer baselines.

Probing the central power sources of ULIRG nuclei using Spitzer-IRS

Henrik Spoon
Cornell University

Ultraluminous Infrared Galaxies (ULIRGs) have the power output of quasars yet emit nearly all of their energy in the mid and far-infrared part of the spectrum. Most ULIRGs are found in interacting and merging systems, where the merger has driven gas and dust towards the remnant nucleus, fueling a massive starburst, and either creating or fueling a nascent AGN.

The study of deeply obscured (U)LIRG nuclei has greatly benefitted from the availability of the IRS spectrograph on the Spitzer Space Telescope. Given its unprecedented sensitivity and wavelength coverage, the IRS enabled us to study the emission and absorption features of various gas phase molecules (e.g. CO, C₂H₂, HCN), water ice, hydrocarbons (both aromatic and aliphatic) and (crystalline) silicates, arising in the dense molecular clouds surrounding the buried central power sources. The availability of these tracers allows us to gain insight in the nature and distribution of the obscuring gas and dust and the energy sources buried among them.

Luminous buried AGNs in the local universe

Masatoshi Imanishi

National Astronomical Observatory of Japan

Although AGNs obscured by torus-shaped dust, with well-developed narrow line regions (NLRs), are easily detectable through optical spectroscopy, most AGNs at the center of dusty galaxies (e.g., ultraluminous infrared galaxies; ULIRGs) can be deeply "buried" in all sightlines. Such buried AGNs are very difficult to find, but are predicted to be abundant in the universe, based on the CXB spectrum. We have performed systematic infrared 3-4 micron (Subaru 8.2m) and 5.2-35 micron (Spitzer) low-resolution spectroscopy of nearby ($z < 0.15$) ULIRGs without previously known AGN signatures in the optical. In addition to investigating the equivalent widths of PAH emission features (the conventional AGN-starburst classification method), we have compared the optical depths of dust absorption features at different infrared wavelengths, in order to distinguish whether the energy source is more centrally concentrated than dust (a buried AGN) or energy sources and dust are spatially well mixed (a starburst). We have found luminous buried AGN signatures in roughly 50% of the observed nearby ULIRGs, strongly suggesting that luminous buried AGNs are common in the local universe (Imanishi et al. 2006 ApJ 637 114; Imanishi et al. 2007 ApJS in press, astro-ph/0702136).

IRS spectroscopy of 3CR radio galaxies and quasars

Martin Haas

University Bochum

With the Spitzer Space Telescope Infrared Spectrograph (IRS) we have observed seven powerful FR2 radio galaxies and seven quasars. Both samples, the galaxies and the quasars, are comparable in isotropic 178 MHz luminosity and in redshift range.

From our pilot study we find for both samples similar distributions in the luminosity ratios of high- to low-excitation lines $[\text{NeV}]/[\text{NeII}]$ and of high-excitation line to radio power $[\text{NeV}]/\text{P178MHz}$. This solves the long debate about the apparent difference of quasars and radio galaxies in favor of the orientation-dependent unified schemes. Furthermore, the average luminosity ratio $[\text{OIII}]5007\text{\AA}/[\text{OIV}]25.9\mu\text{m}$ of the galaxies is by about a factor 3-5 lower than that of the quasars. This suggests that the optical emission from the central NLR is essentially absorbed ($A_V > 3$) in the powerful FR2 galaxies and that the optical $[\text{OIII}]$ luminosity does not serve as isotropic tracer for testing the unified schemes.

Session 3: Lessons from Local AGN

Wednesday 6 June 2007

Lessons form local AGN

Raffaella Morganti

Netherlands Foundation for Research in Astronomy - ASTRON (NL)

Kapteyn Institute Groningen (NL)

Of course we have learnt many lessons from local AGN! In this talk I will focus on some of the results from gas - mainly neutral hydrogen, but also ionised gas.

I will start from the large-scale gaseous structures that we have detected around both radio-loud and radio-quiet galaxies. These structures can be used to learn about the origin and evolution of these galaxies. In particular, their size and their regular kinematics imply that the gas has settled in these galaxies several Gyr ago. At least in some cases, (major) mergers are the most likely origin. The relation with the presence of radio-loud AGN and the radio morphology (compact, FRI, FRII) will be discussed.

I will then move to the central regions where in several local radio-loud objects we were able to discover fast (> 1000 km/s) outflows of neutral hydrogen (and ionised gas). These outflows are tracing the presence of a rich and clumpy interstellar medium in the centre of these radio sources. The characteristics of these outflows (e.g. mass outflow rate) and the possible effect on the evolution of the host galaxy is also discussed.

**Understanding the mid- to far-IR properties of AGN:
deep Spitzer observations of a complete sample of southern radio
galaxies**

Clive Tadhunter

University of Sheffield

The uncertainty surrounding the nature of the heating mechanism for the dust that emits at mid- to far-IR (MFIR) wavelengths in active galaxies limits our understanding of the links between AGN and galaxy evolution, as well as our ability to interpret the prodigious infrared and sub-mm emission of some of the most distant galaxies in the Universe. I will present the results from a deep Spitzer Space Telescope survey of a complete sample of 47 powerful 2Jy radio sources which have a direct bearing on these issues. The general implications of the results for understanding the heating of the cool/warm dust, the links between starburst and AGN activity, and triggering of AGN will be discussed.

A connection between AGN activity and nuclear star formation in Seyfert Galaxies

Richard Davies

MPE

We present results from a survey of 9 nearby AGN using the near infrared adaptive optics integral field spectrograph SINFONI. These data enable us to probe the distribution and kinematics of the gas and stars at spatial resolutions as small as 0.085" (less than 10pc in some objects). We find strong evidence for recent but short lived starbursts residing in very dense nuclear disks. We argue that these would have reached Eddington-limited luminosities when active, and discuss why their duration must be short. We show that there appears to be a delay of 50-100Myr between the onset of the nuclear starburst and the subsequent fuelling of the massive black hole. We consider what causal mechanism might be responsible for this connection between the two phenomena.

Keck Observations of Type-2 AGNs

Hien Tran

W. M. Keck Observatory

I will present recent results of a spectropolarimetric survey of Seyfert 2 galaxies and low-luminosity AGNs at Keck Observatory to search for obscured broad-line regions. Augmented with near-infrared spectroscopy, and at a factor of 10 greater in depth, this survey will significantly improve upon previous ones, and will address the question of whether or not "true" or "naked" Seyfert 2s do exist in nature. In addition, some results from recent observations using the Keck laser guide star adaptive optics (LGS-AO) of obscured AGNs will be presented.

Spitzer Observations of the 12-micron Sample of Seyfert Galaxies

Chris O’Dea

Rochester Institute of Technology

We are conducting a large observing program with the Spitzer Space Telescope to determine the mid- to far-IR spectral energy distributions of a well-defined sample of 87 nearby, 12 micron-selected Seyfert galaxies. We present the results of Spitzer IRAC imaging, IRS low-resolution spectroscopy, and MIPS SED observations. We find that the spectra clearly divide into groups based on their continuum shapes and spectral features. The largest group (about half of the sample) shows a very red continuum suggestive of cool dust and strong emission features attributed to polycyclic aromatic hydrocarbons. About 30% have a power-law continuum with spectral indices of $\alpha(5-20 \mu\text{m}) = -2.3$ to -0.9 that flatten to $\alpha(20-35 \mu\text{m}) = -1.1$ to 0.0 at $\sim 20 \mu\text{m}$. Clear silicate emission features at 10 and 18 μm are found in several of these objects (e.g., Mrk 6 and Mrk 335). A further 16% of the sample show power-law continua with unchanging slopes of $\alpha(5-35 \mu\text{m}) = -1.7$ to -1.1 . Two objects are dominated by a broad silicate absorption feature. Some spectral features are clearly related to a starburst contribution to the IR spectrum, while the mechanisms producing observed power-law continuum shapes, attributed to an active galactic nucleus (AGN) component, may be dust or nonthermal emission. The IR spectral types appear to be related to the Seyfert types. Principal component analysis results suggest that the relative contribution of starburst emission may be the dominant cause of variance in the observed spectra. The derived starburst component of each spectrum, however, contributes $<40\%$ of the total flux density. We compare the IR emission with the optically thin radio emission associated with the AGN and find that Seyfert 1 galaxies have higher ratios of IR to radio emission than Seyfert 2 galaxies, as predicted by the unified model if the torus is optically thick in the mid-IR. However, smooth-density torus models predict a much larger difference between Seyfert types 1 and 2 than the factor of 2 difference observed in our sample; the observed factor of ~ 2 difference between the type 1 and type 2 galaxies in their IR-to-radio ratios above 15 μm requires the standard smooth-density torus models to be optically thin at these wavelengths. However, the resulting low torus opacity requires that the high observed columns detected in X-ray absorption be produced in gas with a very low dust-to-gas ratio (perhaps within the dust sublimation region). On the other hand, our observations may be consistent with clumpy torus models containing a steep radial distribution of optically thick dense clumps. The selection of our sample at 12 μm , where the torus may be optically thick, implies that there may be orientation-dependent biases in the sample; however, we do not find that the sample is biased toward Seyfert 2 galaxies with more luminous central engines, as would be expected. We find that the Seyfert 2 galaxies typically show stronger starburst contributions than the Seyfert 1 galaxies in the sample, contrary to what is expected based on the unified scheme for AGNs. This may be due to the selection effect that only those Seyfert 2 galaxies with strong starburst contributions had high enough integrated 12 μm flux densities to fall above the flux limit of the sample.

Session 4: AGN Feedback

Thursday 7 June 2007

AGN feedback mechanisms: an observational perspective

Matt Lehnert

GEPI, Paris Observatory

I review the observational evidence and manifestations of feedback from AGN. The energy output from AGN effect their galactic environment on a very wide range of scales. I discuss the observational evidence for AGN feedback and what be the physical mechanisms underlying this feedback. As part of these arguments, I address several general questions about the impact of AGN on galaxies and larger structures.

AGN feedback mechanisms: a theoretical perspective

Volker Springel

MPA

It is now widely appreciated that there is a tight link between the growth of galaxies and their embedded supermassive black holes. This suggests that any successful theory of galaxy formation needs to address the joint evolution of galaxies and black holes, and account for their mutual feedback processes. I will review recent theoretical progress in constructing unified models for AGN feedback in cosmological hydrodynamical simulations of structure formation. In particular, I discuss different models suggested for "quasar-mode" and "radio-mode" feedback, and their relative effects on the growth of black holes and their host systems. The simulations indicate that AGN feedback may provide a solution to the cooling flow problem in clusters of galaxies, and also explains the observed scaling relations between black hole masses and bulge properties.

Kinetic luminosity, jet production efficiency and feedback properties of growing black holes

Andrea Merloni

MPA, MPE

The growth of supermassive black holes (SMBH) through accretion is accompanied by the release of enormous amounts of energy which can either be radiated away, as in Quasars, advected into the black hole, or disposed of in kinetic form through powerful, collimated outflows called jets, as observed in Radio Galaxies. The feedback exerted by such a powerful energy release on the surrounding gas and stars is imprinted in the observed correlations between black hole mass and galaxy properties, as well as in the disturbed morphology of the hot, X-ray emitting atmospheres of groups and clusters. Mechanical feedback from growing black holes is most likely responsible for the heating of baryons within the deepest dark matter potential wells, thus regulating both cooling flows in galaxy clusters and the observed sizes and colors of the most massive galaxies. However, the kinetic luminosity of an AGN is itself very difficult to estimate reliably. Only recently have deep X-ray exposures of nearby ellipticals and clusters allowed its first direct estimates by studying the cavities, bubbles and weak shocks generated by radio emitting jets in the intra-cluster medium. Based on such a sample, we present here a new, robust estimator of the kinetic power of a SMBH based on its nuclear properties alone, namely its mass and instantaneous X-ray and/or radio core luminosity. We then derive the intrinsic kinetic luminosity function for flat spectrum radio jets (cores), and found that the total integrated jet power at $z = 0$ is $W_{\text{tot}} \approx 3 \times 10^{40} \text{ ergs s}^{-1} \text{ Mpc}^{-3}$, more than an order of magnitude larger than the current best estimate of the total integrated Supernovae power. By integrating W_{tot} over red-shift, we determine also the total energy density deposited by jets, e_{tot} . We find that both W_{tot} and e_{tot} are dominated by *low* luminosity sources. Comparing e_{tot} to the local black hole mass density ρ_{BH} gives an average jet production efficiency of $\epsilon_{\text{jet}} = e_{\text{jet}}/\rho_{\text{BH}}c^2 \approx 3\%$. Since black hole mass is accreted mainly during *high* luminosity states, ϵ_{jet} is likely much higher during low luminosity states.

Immense Outflows in High-Redshift Radio Galaxies: The “Smoking Gun” of AGN Feedback

Nicole Nesvabda

Observatoire de Paris – GEPI

AGN feedback is a major component of many models of galaxy evolution, tailored to solve some of the outstanding mysteries in the evolution of massive galaxies. However, direct observational constraints are very rare, in particular at the formation epochs of massive galaxies at high redshift. Hence, fundamental questions regarding the importance and physics of such feedback remain.

We obtained integral-field spectroscopy of the rest-frame optical emission line gas in a sample of powerful radio galaxies at $z=2-3.5$. High-redshift radio galaxies are ideal targets to search for the “smoking gun” evidence of AGN feedback in the early universe. All their properties suggest that they are massive galaxies in a phase of rapid growth. They also host powerful AGN, and hence may be sites of exceptionally strong AGN feedback. In our sample we find immense, kpc sized, spatially well resolved outflows of $\sim 10^9 M_{\odot}$ of ionized gas. Geometry, timescale, and energy arguments indicate that these outflows are related to the AGN, and probably driven through the mechanical energy of the radio jet. With kinetic energies of $> \sim 10^{60}$ ergs, sufficient to unbind significant gas masses, and velocities of up to 1000 km s^{-1} , these outflows will potentially escape even the most massive halos. I will present our analysis and discuss the cosmological implications of such significant feedback.

The recent star formation of host galaxies with accreting black holes

Vivienne Wild

Max Planck Institut fuer Astrophysik

A popular model for the coevolution of bulges and supermassive black holes is one in which a galaxy merger leads to the inflow of gas which fuels a strong starburst, followed by an AGN phase in which the black hole grows significantly. I will present recent results from the SDSS spectroscopic galaxy catalogue, which use a new, high signal-to-noise ratio spectral diagnostic of recent star formation history, to show that the majority of low redshift black hole accretion in Type II AGN occurs under less spectacular circumstances. However, a small number of galaxies (<10% of our sample of ~ 34000) which are undergoing, or have recently undergone, a major star formation episode, have the highest average black hole growth rates and show evidence for recent strong interactions and mergers in their light distributions. A significant fraction of this black hole growth occurs in AGN with high amounts of dust extinction, often coinciding with an old, post-starburst stellar population.

Observing AGN Feedback in Action in Early-type Galaxies

Kevin Schawinski

Oxford University

AGN feedback has now been identified as a key ingredient in galaxy formation models, as a mechanism for the suppression of star-formation and for the reproduction of observed scaling relations and downsizing patterns in the local galaxy populations. While theoretical models are now numerous and successful in curing some of the problems of galaxy formation, they are still poorly constrained by observations. This project aims to fill this gap. We analyse the star-formation histories of a large sample of morphological early-type galaxies selected from SDSS and covered by GALEX and 2MASS. Using their optical emission lines, we identify many AGN and star-forming intermediate-mass early-types that are most likely post-merger systems that have formed a significant fraction of their stellar populations in the last 1 Gyr. We relate their star-formation histories to the activity of the AGN and quantify the time- and mass-scales involved in AGN feedback. For the first time, we directly observe the truncation of star-formation in these objects when the AGN turns on. Our results provide us with a very direct measure of the time-scale on which the interplay between star formation and AGN feedback must have operated in early-type galaxies and their progenitors over the last third of the age of the universe.

The difference between radio-loud and radio-quiet AGN

Marek Sikora

N. Copernicus Astronomical Center, Warsaw

We show that AGN form two distinct and well separated sequences on the radio-loudness – Eddington-ratio plane. The upper sequence is composed of radio-loud quasars and radio galaxies, while the lower one consists of radio-quiet quasars, Seyfert galaxies, and LINERs. Such a double pattern can be explained assuming that production of relativistic jets is mediated by spinning black holes and that black holes rotate much more slowly in spiral galaxies than in giant ellipticals. We discuss a possible evolutionary scenario which may lead to such a spin-distribution dichotomy.

The galaxy-morphology related radio-dichotomy breaks down at high accretion rates where most of the luminous quasars are radio-quiet, despite being hosted by elliptical galaxies. It can result from suppression and intermittency of jet activity at high accretion rates, as is directly observed in some black hole X-ray binaries.

Session 3: Lessons from Local AGN

(Continued)

The lurking black hole in the Galactic center

Reinhard Genzel

Max Planck Institute for Extraterrestrial Physics, Garching

In the past decade high resolution measurements in the infrared employing adaptive optics imaging on 10m telescopes have allowed determining the three dimensional orbits stars within ten light hours of the compact radio source SgrA* at the Center of the Milky Way. These observations show that SgrA* is a three million solar mass black hole, beyond any reasonable doubt. The Galactic Center thus constitutes the best astrophysical evidence for the existence of black holes which have long been postulated, and is also an ideal 'lab' for studying the physics in the vicinity of such an object. Remarkably, young massive stars are present there and probably have formed in the innermost stellar cusp. Variable infrared and X-ray emission from SgrA* are a new probe of the physics and space time just outside the event horizon.

Session 5: Extended Structures

Thursday 7 June 2007

Ly- α excess in high redshift radio galaxies: a signature of star formation

Montserrat Villar-Martín

Instituto de Astrofísica de Andalucía

About 54% of radio galaxies at $z>3$ and 8% of radio galaxies at $2<z<3$ show unusually strong Ly- α emission, compared with the general population of high redshift ($z>2$) radio galaxies. These Ly- α excess objects (LAEs) show Ly- α /HeII values consistent with or above standard photoionization model predictions. I'll show that the most successful explanation is the presence of a young stellar population which provides the extra supply of ionizing photons required to explain the Ly- α excess.

I'll argue that although the fraction of LAEs may be incompletely determined, both at $2<z<3$ and at $z>3$, the much larger fraction of LAEs found at $z>3$ is a genuine redshift evolution and not due to selection effects. Therefore, our results suggest that the radio galaxy phenomenon is more often associated with a massive starburst at $z>3$ than at $z<3$.

Metallicity of NLRs in high- z narrow-line radio galaxies

Tohru Nagao

National Astronomical Observatory of Japan

Although gas metallicity of BLRs in high- z type-1 quasars has been investigated extensively, NLR metallicity in high- z type-2 AGNs has not been studied so far. In this contribution, we report our recent analysis on the NLR metallicity in narrow-line radio galaxies at high redshift. The main results are as follows: (1) a diagnostic diagram of CIV/HeII vs CIII]/CIV is useful to study the NLR metallicity, (2) the NLR metallicity correlates with the AGN luminosity, and (3) the NLR metallicity show no evidence for the redshift evolution in the range $1.2 < z < 3.8$.

The nature of radio-quiet Lyman alpha blobs

Yuichi Matsuda

Department of Astronomy, Kyoto University

We present results of recent observations of radio-quiet Lyman alpha blobs. We carried out deep, panoramic narrow-band imaging of the protocluster at $z=3.1$ in SSA22 with the Subaru Suprime-Cam. We detected 33 new radio-quiet Lyman alpha blobs larger than 30 kpc, as well as the two previously known giant (>100 kpc) blobs. These observations increased the number of radio-quiet Lyman alpha blobs by more than an order of magnitude over previous surveys. Almost all of the blobs are located in large-scale filamentary structures of compact star-forming galaxies. Especially, the two giant radio-quiet blobs are located near the intersection of these filaments, which presumably evolves into a massive cluster of galaxies in the local universe. Both high redshift radio galaxies and radio-quiet Lyman alpha blobs may be characteristic phenomenon in overdense environments. We found that Lyman alpha velocity widths of the radio-quiet blobs range between 500 km/s and 1700 km/s with the Keck DEIMOS. Unlike high redshift radio galaxies, the radio-quiet blobs show a correlation between the Lyman alpha velocity widths and the Lyman alpha spatial extents. We detected bright submillimeter emissions for about 30% of the radio-quiet blobs with the JCMT SCUBA, suggesting that intensive starbursts ($1000 M_{\odot}/\text{yr}$) occur in the blobs. We found evidence that submillimeter emission of one of the two giant radio-quiet blobs, SSA22 LAB1, extends to about 40 kpc with the SMA. The most likely explanation of the spatially extended submillimeter emission is that starbursts occur throughout the large area of LAB1. The spatial extent of the submillimeter emission of LAB1 is similar to those of high redshift radio galaxies but much larger than those of submillimeter galaxies. Both giant Lyman alpha halos often seen around radio galaxies and giant radio-quiet Lyman alpha blobs may be partly due to spatially extended starbursts induced by interactions and mergers of gas clumps in overdense environments.

Giant Lyman- α haloes around $z > 2$ radio galaxies: evidence for infall

Andrew Humphrey

Instituto de Astronomia, Universidad Nacional Autonoma de Mexico

I will present our recent investigation into the relationship between side-to-side asymmetries of powerful radio galaxies at high redshift, with the goal of understanding the geometry, orientation and gas dynamics of these sources. Our sample consists of 11 radio galaxies at $z=2.3-3.6$ previously known to have giant, kinematically quiescent nebulae.

We identify several correlated asymmetries: on the side of the brightest radio jet and hotspot (i) the redshift of the kinematically quiescent nebula is highest, (ii) Ly- α is brighter relative to the other lines and continuum, (iii) the radio spectrum is flattest and (iv) the radio structure has its highest polarization. These asymmetries are not found to be correlated with either the radio arm length asymmetry or the brightness asymmetry of the UV-optical emitting material.

Collectively, these asymmetries are most naturally explained by orientation effects, with the quiescent nebulae in infall. The implied rate of gas infall is more than sufficient to power the luminous active nucleus and also the tar-forming activity seen in (some) high- z radio galaxies.

Based on a paper accepted by MNRAS: <http://xxx.lanl.gov/abs/astro-ph/0611778>

Session 6: Host galaxies properties

Thursday afternoon

Stellar properties of host galaxies

Tim Heckman

Dept. of Physics and Astronomy, Johns Hopkins University

Properties of High Redshift Radio Galaxies from Longwavelength Observations

Nicholas Seymour

Spitzer Science Center

We have systematically studied 70 Radio Galaxies across $1 < z < 5.2$ in the infrared with Spitzer, in the sub-mm and at radiowavelengths. The Spitzer data allows us to decompose the rest-frame optical to IR spectral energy distribution into stellar, AGN and dust components and determine the contribution of host galaxy stellar emission to the rest-frame H-band. The resultant stellar luminosities imply stellar masses of $10^{11-12} M_{\odot}$ at all redshifts, indicating that radio galaxies form early and are amongst the most massive at these epochs. These powerful radio galaxies tend to lie in a similar region of IRAC colour-colour space as unobscured AGN, despite the stellar contribution to their short-wavelength mid-IR SEDs. The exceptionally high mid-IR luminosities are consistent with an obscured, highly accreting AGN. We compare these results with quantities derived from the sub-mm (eg cold dust temperature and masses) and the radio (luminosity, lobe size) data, and discuss some correlations, eg stellar mass with radio luminosities, mid-IR luminosity with radio lobe size.

High Resolution Molecular Spectroscopy of Submillimeter Galaxies

Linda Tacconi

MPE, Garching

We present sub-arcsecond resolution IRAM PdBI interferometry of submillimeter galaxies at $z \sim 2$ to 3.4, where we detect continuum at 1mm and/or CO lines at 3 and 1 mm. The CO 3-2/4-3 line profiles in several of the sources are double-peaked, indicative of orbital motion either in a single rotating disk or of a merger of two galaxies. The millimeter line and continuum emission is compact; we marginally resolve the sources or obtain tight upper limits to their intrinsic sizes in all cases. The median FWHM diameter is $0.5''$ (4 kpc). In two cases we have been able to spatially and kinematically resolve the source into two distinct components that are very likely in the process of a major merging event.

Our measurements clearly show that the submillimeter galaxies we have observed resemble scaled-up and more gas rich versions of the local Universe, ultra-luminous galaxy (ULIRG) population. Their central densities and potential well depths are much greater than in other $z \sim 2-3$ galaxy samples studied so far. They are comparable to those of elliptical galaxies or massive bulges. The SMG properties fulfill the criteria of “maximal” starbursts, in which most of the available initial gas reservoir of $10^{10}-10^{11}$ solar masses is converted to stars on a time scale $\sim 3-10 t_{dyn} \sim$ a few 10^8 years.

The Role of Tidal Interactions and Mergers in Triggering Starbursts and AGN

Guinevere Kauffmann

Max Planck Institute for Astrophysics

One very popular paradigm is that AGN are triggered during galaxy-galaxy interactions or mergers, when gas is driven into the center of the galaxy and is able to trigger a starburst and feed the central black hole. We have been exploring the extent to which this paradigm holds in the local Universe using starburst galaxies and AGN selected from the Sloan Digital Sky Survey.

The Spitzer view on high-redshift dusty galaxies: AGN contribution and its connection with star formation, large-scale properties and masses of the hosts

Manuela Magliocchetti

INAF, OATS & ESO

A multiwavelength-analysis of the ~ 800 optically invisible ($R > 25.5$) sources observed at 24 μm by the Spitzer First Look Survey (Fadda et al. 2006) reveals that their majority is made of ultraluminous far-IR galaxies located in the redshift range $z = [1.6-2.7]$. However, about 20% of the sample shows evidence for a relevant AGN activity hidden by dust. The properties of these objects (from number counts to redshift distribution) are fully consistent with those of proto-spheroidal galaxies in the process of forming their stars and growing their active nucleus. The dimension of the sample allows for the first time high precision estimates of the clustering properties of high-redshift dusty galaxies and determinations of their masses. We find that the amplitude of their spatial correlation function is very high: the associated comoving length is $r_0 \approx 14$ Mpc (comoving), value which puts these objects amongst the most strongly clustered populations in our known universe. No difference is found in the clustering properties of sources mainly powered by pure star-formation processes and for those objects presenting a more relevant AGN contribution, evidence which strongly favours an evolutionary link between star-formation activity and AGN formation and evolution in high-redshift galaxies. Matches of the observed correlation function with theoretical models furtherly show that these sources have to be hosted by dark matter haloes more massive than $10^{13.4} M_{\odot}$. This value is significantly higher than that for the typical galactic haloes associated to massive elliptical galaxies, suggesting a duration of the star-burst phase of massive high-redshift dusty galaxies of $T_B \approx 0.5$ Gyr and $T_{AGN} \approx 0.1$ Gyr for what concerns 'dark' AGN accretion.

Session 7: Global picture

Friday 8 June 2007

Observations of AGN and their environment with Future VLT and E-ELT Instruments

Sandro D'Odorico

ESO, Garching

AGN-related observations are prominent in the science cases of three of the 2nd generation VLT Instruments (X-shooter, KMOS and MUSE). The 42m E-ELT instruments now being studied have also a great potential in this field due to the angular resolution down to 10 mas in the K band provided by the telescope when used with Adaptive Optics. The impact of these new facilities on our understanding of the physics of the AGN is expected to be very significant. An overview of the currently planned observing programs with the different instruments is presented.

Cosmic evolution of AGN

Guenther Hasinger

Max-Planck-Institut für extraterrestrische Physik, Garching

The X-ray sky is dominated by a diffuse extragalactic background radiation, which our team, together with others, was able to resolve almost completely into discrete sources using the X-ray satellites ROSAT, Chandra and XMM-Newton - we observe the growth phase of the population of supermassive black holes throughout the history of the Universe. A significant fraction of this growth occurs in obscured AGN, but there is a strong trend of less obscuration with increasing luminosity. Also the evolution of obscuration seems to be less strong than previously claimed. Taking all the recent ingredients together, a new X-ray background population synthesis model could be derived, which gives a self-consistent description of all observational multiwavelength-constraints. Indeed, the mass distribution of black holes in local galaxies is well traced by the evolution of the accreting black hole luminosity function. However, the maximum of high-luminosity objects occurs significantly earlier in the history of the universe, than that of low-luminosity objects, which have a peak at redshifts below unity. This anti-hierarchical evolution is similar to the down-sizing effect observed in the optical galaxy population and still awaits a theoretical explanation.

The Correlation Between the Hard X-ray Photon Index and the Accretion Rate in AGN: Probing Black-Hole Growth Across Cosmic Time

Ohad Shemmer

The Pennsylvania State University

We present new XMM-Newton observations of six luminous and high accretion-rate radio-quiet AGN at $z \sim 2.5$. Together with archival X-ray and rest-frame optical spectra of four sources with similar properties as well as 25 moderate-luminosity radio-quiet AGN at $z < 0.5$, we investigate, for the first time, the dependence of the hard ($> \sim 2$ keV) X-ray power-law photon index on the broad $H\beta$ emission-line width and on the accretion rate across ~ 3 orders of magnitude in AGN luminosity. We find that the photon indices of the luminous, high-redshift sources, while consistent with those expected from their accretion rates, are significantly higher than expected from the widths of their $H\beta$ lines. We argue that the hard-X-ray photon index depends primarily on the accretion rate and that this dependence, together with X-ray photon-index measurements available for many AGNs in deep and wide surveys, can provide a powerful probe for tracing the history of black-hole growth across cosmic time. We apply this method to the type-I and type-II AGN populations in the Chandra Deep Fields and show a comparison between the accretion-rate distributions as a function of redshift, luminosity, and black-hole mass and current models of black-hole growth.

Understanding the Far-IR & Sub-mm Spectra of Obscured AGN

Brent Groves

Leiden Observatory

Our understanding of buried AGN relies heavily upon observations made in the IR to sub-mm band of wavelengths. Here, we present theoretical models of narrow line regions, compact HII regions and evolved starburst complexes with the view to untangling the energetic contributions of each of these in the 5 - 1000 micron wavelength range. We will discuss diagnostics based upon both emission lines and upon broad-band continuum measurements, and what physical parameters may in principle be derived from these diagnostics.

The Evolution of AGN Obscuration

Ezequiel Treister

ESO, Chile

One fundamental ingredient in our understanding of the AGN population is the ratio of obscured to unobscured AGN and whether this ratio depends on other parameters like intrinsic luminosity or redshift. Observationally, deep X-ray surveys found that the obscured AGN fraction depends on luminosity. However, the dependence on redshift is less clear. In this work, we constructed the largest sample to date of AGN selected in hard X-rays, containing a total of 1229 sources, 631 of them obscured, with a high spectroscopic completeness in order to study the possible dependence of the fraction of obscured sources with redshift and/or luminosity. We confirm that this fraction decreases with increasing luminosity as previously reported and found that at the same time it increases with increasing redshift. This is the first time that this evolution is significantly detected using only optical spectroscopy to separate obscured and unobscured AGN. Additionally, we use the spectral shape and intensity of the X-ray background as a separate constraint on the evolution of the obscured AGN fraction finding consistent results. This can be interpreted as an evolution in the location of the obscuration, from the central parsec-scale region (the torus) at low redshift to kiloparsec scales (the host galaxy) at high redshift, as it is known that most galaxies contained more dust in the past.

Additionally, using a large sample of Sloan Quasars at $z \sim 1$ with Spitzer observations, we found an increase in the relative fraction of mid-IR flux with decreasing bolometric luminosity, suggesting that the dependence of the obscured AGN fraction with luminosity can be due to a change in the opening angle.

Statistics of local hard X-ray selected AGN: implications for the CXB and unification model

Sergey Sazonov

Max-Planck Institute for Astrophysics

The recently completed INTEGRAL hard X-ray all-sky survey provides, for the first time, a sample of more than 100 nearby AGN selected without regard to absorption effects. We will report a number of results from this survey, including the hard X-ray luminosity function, column density distribution and large-scale spatial distribution of AGN in the local Universe. We will also present a composite hard X-ray spectrum of local AGN and discuss the implications for the cosmic X-ray background. Finally, we will show preliminary results of cross-correlating the hard X-ray fluxes of our AGN with measurements in other wavebands, in particular in the standard X-rays with Chandra and in the infrared with Spitzer, with the aim of testing the AGN unification model and obtaining a representative SED of local AGN.

Observations and simulation predictions of the large scale environment of radio galaxies and quasars at high redshift

Roderik Overzier

The Johns Hopkins University

The spatial distribution of galaxies shows a substantial level of substructure on cluster-sized scales already at high redshift. In some cases, this large scale structure is traced by radio galaxies or luminous quasars. How unique are these structures, how may we find them, and what are the properties of their present-day descendants? We use the Millennium Run simulations to construct observed lightcones mimicing typical observations of deep fields containing some of the most massive structures present at $z=4-6$, and compare with recent observations of the large scale environment of radio galaxies at $z\sim 4$ and quasars at $z\sim 6$.

The Environments of High-Redshift AGN

Andrew Zirm

The John Hopkins University

Distant active galaxies have provided excellent signposts for high-redshift galaxies overdensities, i.e., protoclusters. I will review the current state of AGN-based protcluster surveys and summarize the follow-up observations and results now underway. In particular I will discuss the color-magnitude diagram of a $z=2.16$ protocluster situated around the powerful radio galaxy MRC 1138-262 and the MIPS imaging of the 4C 23.56 field which shows an intriguing overdensity of IR-luminous sources.

Short Talks

Tuesday 5 June 2007

&

Wednesday 6 June 2007

Emission from Shock Excited Gas in Active Galaxies

Mark Allen

Observatoire de Strasbourg

Shocks driven by AGN outflows and jets can have significant effects on the host galaxy, and are important for understanding the overall energetics. I will present the new MAPPINGS III library of shock models. These models cover a wide range of pre-shock density, abundances and magnetic field for shocks with velocities up to 1000 km/s. I show how these models can be compared to current large AGN survey data to help disentangle the various physical processes in these galaxies.

Extended Lyman-alpha haloes around radio-quiet objects

Andrew Bunker

University of Exeter, School of Physics

We have discovered extended Lyman-alpha haloes around radio-quiet QSOs at high-redshift (including one at $z=4.5$). The size and Lyman-alpha luminosities are similar to the Lyman-alpha blobs found in narrow-band imaging, some of which may be obscured AGN. We will discuss how these populations may be related, and what powers the Lyman-alpha emission (the AGN, star-formation, or the UV background).

Black holes in galaxy formation and evolution

Andrea Cattaneo

AIP, Potsdam

I include the cold/hot flow bimodality and the growth of super massive black holes in N-body/semi-analytic simulations of galaxy formation. I demonstrate that the shutdown of the hot mode is an essential requirement to explain the red colours of early-type galaxies and the rarity of luminous low red shift AGNs. AGN feedback can induce this cooling shutdown either as a blowout scenario or in the form of self-regulated black hole accretion. This picture with two galaxy formation regimes predicts an AGN bimodality with QSOs on the one hand and radio galaxies on the other. I compute the equilibrium temperature at which AGN heating balances cooling. An argument that compares the equilibrium temperature with the virial temperature naturally reproduces the black hole masses of the galaxies in clusters. I also present the results of adaptive-mesh-refinement and smoothed-particle-hydrodynamics simulations. These simulations demonstrate that self-regulation is a general property of models with AGN feedback. My analytic and numerical results converge to the conclusion that AGN feedback plays an essential role in unified scenarios of black hole growth and the formation of the red galaxy population. I shall discuss the distinction between obscured and unobscured AGNs from this galaxy formation perspective.

Multi-wavelength study of AGN in the UKIDSS Ultra Deep Survey

Michele Cirasuolo

Institute for Astronomy Edinburgh University

We present a detailed analysis of obscured and un-obscured AGN selected from the UKIDSS/Subaru/XMM Survey. In particular we focus on the properties of the active nuclei as a function of redshift and their host galaxy stellar mass derived from the unique deep multi-wavelength photometry in optical and near-IR available for this field. The issue of the presence of heavily absorbed, Compton-thick sources is also briefly addressed within the framework of the unified scheme. Finally, exploiting deep radio data down to 7 μ Jy/beam rms we tackle the issue of the sub-mJy radio population and the fraction of AGN at faint radio fluxes.

Obscured radio-loud AGN in the NDWFS Bootes field

Steve Croft

UC Davis / LLNL

I will discuss our investigations using Keck imaging and spectroscopy, and Spitzer imaging, of the host galaxies of optically faint millijansky radio sources. By identifying radio sources with Spitzer IRAC detections, and AGN-like mid-IR colors, that are /faint/ in the deep optical imaging of the NDWFS Bootes field, we preferentially select obscured AGN at $z \sim 2$. By identifying radio sources with IRAC detections that are /invisible/ in NDWFS, we select AGN hosted by protogalaxies at $z \sim 5$. These sources are the obscured counterparts to "traditional" high-redshift radio galaxies.

The effect of orientation on the mid to far infrared properties of radio loud AGN.

Daniel Dicken

university of Sheffield

A great advantage of radio loud AGN is that one can select an orientation-unbiased sample based on the steep spectrum extended radio emission, and also get an indication of the true orientation to the line of sight from the ratio of core to extended radio flux. We have used deep Spitzer observations of a complete sample of 48, 2Jy southern radio galaxies to investigate the impact of orientation on the mid-infrared properties of AGN. The results of this study will be presented.

Probing AGN and their Surroundings with Ly- α Observations

Mark Dijkstra

University of Melbourne

Bright quasars surrounded by cold gas may be visible as large Ly- α blobs when a significant fraction of the quasars ionising flux is converted into Ly- α recombination radiation. This provides a simple explanation for (some of) the observed Ly- α “blobs” at $z=2.4-5.0$, which are observed in increasing numbers. Using a Monte-Carlo radiative transfer code, I will discuss insights into the distribution & kinematics of gas in these Ly- α ‘blobs’ that may be provided by observations. I will also discuss how existing surveys of redshifted Ly- α emission from young galaxies have the sensitivity to probe (type I) quasars at $z > 4.5$ at luminosities 7-12 magnitudes fainter than those discovered by SDSS.

How common are obscured AGN at $z\sim 1$?

Jennifer Donley

University of Arizona

A number of multiwavelength techniques have been employed to identify obscured AGN. Each technique, however, draws AGN from different redshift and bolometric luminosity regimes, making it difficult to quantify the true number of heavily obscured AGN in the distant universe. To overcome this limitation, we utilize the plethora of spectroscopic and photometric redshifts in the deep GOODS fields, along with the ultra-deep MIPS imaging, to identify a 12-micron-limited sample at $z\sim 1$. An AGN's 12-micron luminosity is representative of its bolometric luminosity, and is relatively independent of obscuration or AGN type. By applying a number of AGN selection criteria to this sample, we can therefore quantify the fractional contribution of obscured AGN as a function of their bolometric luminosity, and investigate the overlap and efficiency of various selection techniques.

Two-dimensional kinematics of Stars, Ionised and Neutral Gas in Seyfert and Inactive Host Galaxies.

Gaelle Dumas

CRAL Observatoire de Lyon

Given the ubiquity of nuclear black holes, it is surprising that only 10%-20% of local galaxies are active. Black hole reactivation is required and a key unsolved question is whether the ignition mechanism, in particular the fueling material, is related to the host galaxy properties. We are conducting a multi wavelength observational study on a well-defined sample of Seyfert and control inactive galaxies in order to link the atomic gas properties in the outer galactic disc using neutral hydrogen (VLA) with the stellar and ionised gas kinematics within the central kpc using the integral-field spectrograph SAURON. The optical data reveal regular stellar velocity fields in the circumnuclear regions of all the galaxies and global kinematic alignment between stars and gas componets in most galaxies. However complex structures and significant deviations from axisymmetry are identified in the ionised gas kinematics of the Seyfert galaxies, in regions not domina ed by non-gravitational motions driven by the active nucleus. This result may suggest a link between nuclear gaseous streaming and nuclear activity. The comparison of these optical data with our large scale radio data allows us to probe the galactic potential on spatial scale ever-closer to the nucleus, and therefore to identify or eliminate possible triggering and fueling mechanisms.

Red Galaxies Cluster Members around HzRG at $z \sim 1.5$

Audrey Galametz

JPL – ESO Garching

The use of radio galaxies to pinpoint high redshift proto-clusters is now well established. However, most studies have concentrated on $z > 2$, while classical cluster searches have not gone beyond $z = 1.5$. We study the surrounding of three radio galaxies at redshift 1.48, 1.54 and 1.84 based on a multiwavelength dataset obtained for these fields: wide field imaging in z (LFC/Palomar - $25' \times 25'$), J and Ks imaged with the new WIRCAM camera at the CFHT (mosaic of $25' \times 25'$) and IRAC mid-infrared bands (around $4' \times 4'$). We use colors cuts pertinent at that redshift and determined from galaxy templates and previous studies to select cluster members candidates. The distribution of selected galaxies is not homogenous and a clearly higher concentration of these sources can be seen in at least one of the fields. Furthermore, the selected galaxies trace a clear red sequence in the color-magnitude diagram. At last, studying IRAC bands in particular, we suspect an overdensity of AGN for at least two fields.

The abundance of Compton Thick AGN

Roberto Gilli

INAF - Osservatorio Astronomico di Bologna

We estimate the abundance of Compton Thick AGN in the Universe by means of a detailed and self-consistent modeling of the cosmic X-ray background (XRB). Whereas unobscured and Compton Thin AGN are found to explain most of the XRB emission below 10 keV, they fall short in matching the XRB peak intensity at 30 keV, which can be instead accounted for by a large population of heavily obscured - Compton Thick objects. According to our predictions, the latter class has to be at least as numerous as that of Compton thin AGN over a broad range of redshifts and luminosities. Because of their heavy intrinsic obscuration, Compton Thick AGN are on average much fainter than Compton Thin AGN. Therefore, despite of their large abundance, they are still sparsely detected in current X-ray surveys. We show that the relatively small fractions of Compton Thick AGN observed in the Chandra Deep Field South and in the first catalogs of AGN selected at energies above 10 keV are in excellent agreement with the model expectations. We finally present predictions for the numbers of heavily obscured AGN to be observed in future and on-going deep and wide X-ray surveys performed at energies below and above 10 keV.

Viewing the Molecular Torus in AGN

Erin Hicks

Max-Planck-Institut fuer extraterrestrische Physik

The distribution and kinematics of molecular hydrogen in the nuclei of nine nearby AGN, observed with spatial resolutions down to $0''.085$, are consistent with an obscuring torus. Fits to the flux distributions indicate the gas is in a disk-like distribution with size scales of 10-60 pc, consistent with model predictions. The gas column density at these same radii, estimated to be at least 10^{23} cm^{-2} , is sufficient to provide the needed obscuration of the AGN. The bulk of the molecular hydrogen is in ordered rotation and the 70-130 km s^{-1} velocity dispersion is comparable to, or greater than, the rotational velocity on scales similar to that of the gas disk, suggesting a geometrically thick distribution consistent with obscuring torus models. This vertical structure is likely due to turbulence in the gas caused by heating from the AGN and/or nuclear star formation. The molecular hydrogen is similar in both distribution and kinematics to the nuclear stellar disks, suggesting a torus composed of mixed molecular gas and stars.

The red sequence in proto-clusters associated with radio galaxies at $2 < z < 3$

Jaron Kurk

Max-Planck-Institut fuer Astronomie, Heidelberg

Narrow-band emission line surveys have been very succesful in finding proto-clusters of galaxies associated with distant radio galaxies. However, the more massive, evolved galaxies in these proto-clusters are not identified by this method and have remained elusive, although they may dominate the proto-cluster's mass budget. Using wide-field NIR imaging on Subaru, we have found evidence for the red sequence made up by massive galaxies in four proto-clusters at $2 < z < 3$. The bright end of this sequence is well populated at $z = 2$ but less so at $z = 3$, possibly indicating that the galaxies more massive than 10^{11} solar masses first appeared at $z < 3$.

The history of obscured accretion in the Universe

Fabio La Franca

Università Roma Tre

We will report on the latest results on the cosmological evolution of the density of active galactic nuclei (AGNs) and of their NH distribution. The results are based on the compilation of several X-ray surveys and on the identifications and SED studies of sources detected on fields observed at both mid-infrared (by Spitzer) and X-ray wavelengths. One of these fields is the ELAIS-S1/SWIRE/XMM area where more than 1400 sources were spectroscopically identified at VLT down to $R \sim 24$. Using all these data, we will present the estimate of the history of the total and obscured accretion in the Universe.

On the Origin of Radio Emission in Radio Quiet Quasars

Ari Laor

Technion - Israel Institute of Technology

The radio emission of Radio Loud Quasars originates in a relativistic jet, but the origin of the radio emission in RQQ is not firmly established yet. A mild jet is generally thought to be a likely origin, as high resolution imaging clearly indicate a compact high brightness temperature source, however another origin cannot be excluded. Here we describe some indirect evidence, based on a rather strong correlation between the radio and X-ray emission in RQQ, that the radio emission in RQQ may originates in a magnetically active corona above the accretion disk.

The bolometric output of luminous obscured X-ray sources in the HELLAS2XMM survey: The Spitzer view

Francesca Pozzi

Dipartimento di Astronomia, Bologna

Recent X-ray surveys have provided a significant number of high-luminosity, obscured AGN, the so called Type-2 quasars. Despite the large amount of multi-wavelength supporting data, at present the main parameters related to the central black holes are still poorly known.

Here we present the results obtained for a sample of X-ray selected Type-2 quasars from the HELLAS2XMM survey. Thanks to the new Spitzer IRAC and MIPS data and multiband optical photometry and morphological analysis, we have been able to properly disentangle the nuclear and host galaxy light and to estimate the nuclear Spectral Energy Distributions (SEDs).

The SED analysis has allowed us to compute robust bolometric corrections, and to estimate the black hole mass distribution and Eddington ratios.

Gamma-ray absorption in quasars: a theoretical perspective

Anita Reimer

HEPL/KIPAC, Stanford University

Following the unification scheme, the central nucleus of an active galaxy consists of a black hole, an accretion disk, line-emitting clouds, a dusty torus, and emanates prominent jets when classified as radio-loud. Those radio-loud AGN, blazars and their misaligned counterparts, are characterized by strong, highly variable non-thermal emission from radio up to gamma-ray energies, which is thought to originate in their relativistic jets, and sometimes even extends far into the TeV-band. In many cases the gamma-rays carry the bulk of the total radiative power, at the same time they suffer also from absorption in the radiation fields and matter associated with the AGN environment.

I will provide an overview of the various gamma-ray absorption processes (photon-photon pair production, resonant gamma-ray absorption in matter) that are possible in the settings of radio-loud AGN, and their relevance for diagnostic purposes of their environment. Implications for the blazar population in the broadly unexplored 10-100 GeV range, soon to be studied by the GLAST mission, and for studies of the evolution of the Extragalactic Background Light (EBL) are discussed.

The stellar mass content of radio galaxy hosts at $z\sim 2.5$

Alessandro Rettura

Johns Hopkins University

Unique multiwavelength data (from rest-frame optical to infrared) and spectroscopic measurements available from the SHIZRAG collaboration enable us to study the stellar population properties of the most massive high redshift radio galaxies at $z>2$ in great details. These data allow us to measure the stellar mass of the radio galaxy host by constraining the combined contributions due to scattered quasar light, nebular continuum and young stellar populations. In Villar-Martin et al. 2006, we found for MRC2104-242, a radio galaxy at $z\sim 2.5$, a best-fitting stellar mass estimate similar to the stellar masses found for the most massive, early-type galaxies at $z\sim 2$ in deep, IR surveys, indicating the importance of this class of objects in massive galaxy formation process. We also present new measurements of age and mass for the host of a powerful radio galaxy at $z\sim 2.5$, 4C23.56, and we discuss the impact of more recent calculations of evolutionary tracks of TP-AGB stars (Maraston et al 2005; Charlot & Bruzual 2007) on our previous measurements.

Populations of ULIRG/AGNs from infrared surveys

Brigitte Rocca-Volmerange

Institut d'Astrophysique de Paris

The recent MIR surveys from ISO and Spitzer show a typical flux excess which is a strong signature of evolution. The role of AGN galaxy hosts in this excess is still debated. We shall present the faint galaxy counts observed in the new ISO/12 μ m survey (Rocca-Volmerange et al, astro-ph/0705.2031). The interpretation of ISO/12 μ m, ISO/15 μ m and SPITZER/24 μ m with our code PEGASE.3 (Fioc et al, 2007) allows to distinguish active galaxies from normal galaxies. The role of populations of AGN hosts at high redshifts is clarified and compared to ULIRGs and starbursts. Consequences on masses, star formation and accumulation time-scales will be presented.

The obscured AGN content of the Subaru/XMM-Newton Deep Field

Chris Simpson

Astrophysics Research Institute, Liverpool John Moores University

I will describe the current status of the AGN identification in the Subaru/XMM-Newton Deep Field (also the site of the UKIDSS Ultra Deep Survey), which possesses the deepest optical and near-infrared data of any degree-size survey field. I will compare the results from the identification of radio and X-ray sources and investigate what this tells us about the number of Compton-thick objects.

Evidence of Mergers in Dust-Obscured Type 1 Quasars

Tanya Urritia

UC Davis / LLNL

Dust-reddened Type 1 Quasars present a new and largely uninvestigated quasar population, which may have many members, which are at an earlier stage in their quasar activity in which gas and dust debris from the merger shield the view into the active nucleus. We have carried out surveys to identify these so-called red quasars and have followed them up with Chandra, HST and the VLA. My talk will focus on Hubble ACS images of 13 Type-1 dust reddened quasars selected from the FIRST/2MASS survey. The images show strong evidence of interaction in 11 of the 13 quasars even before performing quasar subtraction. None of the host galaxies fits a perfect elliptical profile. After doing PSF fitting and subtraction, the quasar has even redder colors than inferred from the spectrum. Also, the spectra which fit a dusty starburst reddening curve show the most interaction. The red quasar phenomenon seems to have an evolutionary explanation in that the young quasar spends a fraction of its lifetime enshrouded in an interacting galaxy as has been recently suggested by theoretical simulations. This might be further indication of a link between AGN and Starburst galaxies.

Galaxies, Black Holes & Laboratories: ISM dust in energetic environments.

Wil van Breugel

UC Merced & LLNL

I will report on laboratory studies and numerical simulations of the effects of energetic particles on the properties of interstellar dust. This provides new diagnostics for observations of energetic feedback by starbursts and AGN on their environment.

Discovery of obscured, luminous $z \sim 2$ quasars in the infrared UKIDSS Large Area Survey

Bram Venemeans

Institute of Astronomy

In this talk I will report on the search we have embarked for bright extremely red objects (EROs) using the UKIDSS Large Area Survey. This ongoing project has uncovered at least 10 EROs with $K[\text{Vega}] < 17.0$ which are undetected in the Sloan Digital Sky Survey. Follow up near IR spectroscopy has revealed that the majority of these sources are obscured broad emission line quasars at redshift ~ 2 . These extremely luminous quasars are amongst the most reddened quasars known, and hence are easily missed in optical surveys for Type I AGN. I will discuss the properties of these quasars, including SEDs, optical and infrared spectra and luminosities.

On the infrared properties of dusty torus

Liza Videla

Universidad de Chile, Santiago

We performed imaging on 49 type 2 Seyfert galaxies in 6 near- and mid-infrared bands (1-10 micron). We separated the contribution of the torus from the host galaxy by radial profile fitting techniques and we are comparing the observed spectral energy distributions with theoretical models of torus emission to constrain geometrical and physical parameters.

The quest for Type 2 quasars: What are the X-ray observations of optically selected QSOs2 telling us?

Cristian Vignali

Universita' di Bologna, Dipartimento di Astronomia

Although many Type 2 quasars, the long-sought after "big cousins" of local Seyfert 2 galaxies, have been recently discovered by Chandra and XMM-Newton, till few years ago their number from optical surveys was extremely limited, casting doubts on the efficiency of these surveys in detecting luminous, high-ionization narrow emission-line AGN. Here we present the Chandra and XMM-Newton spectral results of optically selected Type 2 quasars drawn out from two large-area, ground-based surveys, the Sloan Digital Sky Survey and the Palomar Sky Survey. We provide indications that a significant fraction of the X-ray faintest SDSS Type 2 quasars are absorbed by Compton-thick (i.e., $N_{\text{H}} > 10^{24} \text{ cm}^{-2}$) matter.