ABSTRACT BOOK

University of Southampton

Edited by Chris Boon & Francesco Shankar

TORUS 2015 Abstract Book

University of Southampton

14–17 September 2015

Contents

1 Workshop General Information

Workshop Rationale

The torus paradigm has proved to be remarkably successful at unifying the observed zoo of active galaxy (AGN) classes, despite having many manifest holes. The field is still data-driven with novel observational results at multiple wavelengths emerging rapidly. We are only now beginning to map out the structure of dusty gas feeding and obscuring AGN, and to model its evolution in galaxy growth. But these have also brought out several apparently contradictory results which must hold the key to future progress.

As we celebrate 30 years of the paradigm, this is the perfect time to draw together our current knowledge and reassess the state of the field. This will be an international workshop at the University of Southampton, UK, with the objective of laying out the major challenges to the field and paving future research directions. Our hope is to facilitate plenty of informal discussions between multi-wavelength observers and theorists, addressing some key issues:

- What is the main driver in the unification scheme? What are the roles of orientation, mass accretion rate and feedback?
- What is the nature and structure of gas and dust in the torus? Do we have a self-consistent picture across multiple wavelengths?
- How critical is the role of the torus as an interface between small nuclear scales and large galactic scales? Does galaxy evolution necessarily require tori?
- How close are we to self-consistently simulating nuclear activity including AGN feeding and nuclear star-formation?

Workshop Format

The three themes of accretion, orientation, and evolution will be covered through invited and solicited contributions. Different to other conferences, we are building each session around some key papers that have shaped the field or those with great future potential to do so. We specifically pit competing ideas against each other to help painting a realistic picture of the state-of-the-art. Each session will end with discussion rounds delving into important future perspectives. We hope to spark plenty of focused discussion amongst the participants, and the workshop format will allow for this.

Scientific Organising Committee

Almudena Alonso Herrero • Patricia Arévalo • Poshak Gandhi (Co-chair)
Sebastian Hoenig (Co-chair) • Masa Imanishi • Rachel Mason
Chris Packham • Cristina Ramos Almeida • Marc Schartmann
Marko Stalevski • Meg Urry

Local Organising Committee

Diego Altamirano • Chris Boon • Peter Boorman • Sam Connolly
James Matthews • Poshak Gandhi (Co-chair) • Wynn Ho
Sebastian Hoenig (Co-chair) • Sam Mangham • Francesco Shankar
David Williams

Invited Speakers

Robert (Ski) Antonucci • Dave Alexander • Daniel Asmus • Karina Caputi
Santiago Garcia-Burillo • Ric Davies • Moshe Elitzur • Antonis Georgakis
Fiona Harrison • Andrew King • Makoto Kishimoto • Shintaro Koshida
Stefan Kraus • Ari Laor • Stephanie Lamassa • Nancy Levenson
Frederic Marin • Hagai Netzer • Hirofumi Noda • Cristina Ramos Almeida
Claudio Ricci • Yoshihiro Ueda • Beatriz Villarroel • Martin Ward

2 Workshop Programme

Monday 14th – ORIENTATION		
Time	Speaker	Topic
Session I: 9:00-10:20		
Chair: Andy Lawrence		
9:00–9:15		Welcome
9:15–9:40	Robert (Ski) Antonucci	*Polarimetry on life support*
9:45–10:00	Frederic Marin	*Testing the unified model of Agn with broadband polarimetry*
10:05–10:20	Cristina Ramos Almeida	*Upholding the Unified Model for Active Galactic Nuclei: VLT/FORS2 Spectropolarimetry of Seyfert 2 galaxies*
Coffee: 10:25-10:50		
Session II: 10:50-12:10		
Chair: Andy Lawrence		
10:50–11:05	Makoto Kishimoto	*The mid–IR and near–IR interferometry of AGNs: key results and their implications*
11:10–11:20	Konrad Tristram	*Disks and cones: resolving the dusty torus with mid–infrared interferometry*
11:25–11:35	Noel Lopez Gonzaga	*Mid–infrared interferometry of AGN: A statistical view into the dusty nuclear environment of the Seyfert Galaxies*
11:40–11:50	Alberto Masini	*The physics of megamaser AGN*
11:55–12:10		*Flash Discussion*
LUNCH: 12:10-13:30		
Session III: 13:30-14:55		
Chair: Andrew Robinson		
13:30–13:50	**Poster Presentations**	*1–min talks + brief Q&A on posters*
13:50–14:05	Shintaro Koshida	*Reverberation Measurements of the Inner Radius of the Dust Torus in 17 Seyfert Galaxies*
14:10–14:20	Ady Annuar	*Towards A Complete Census of the Compton–thick AGN population and the N_H Distribution of AGN in the Local Universe*
14:25–14:35	Triana Almeyda	*Modeling the Reverberation Response of the Dusty Torus Emission of NGC 6418*
14:40–14:50	Leonard Burtscher	*Obscuration in active galactic nuclei: near–infrared luminosity relations and dust colors*
Coffee: 14:55-15:20		
Session IV: 15:20-16:40		
Chair: Andrew Robinson		
15:20–15:35	Fiona Harrison	*NuSTAR: Probing the Geometry of Obscuration in the High Energy X–ray Band*
15:40–15:50	Alex Markowitz	*First X–ray Statistical Tests of Clumpy Torii Models: Constraints from RXTE monitoring of Seyfert AGN*
15:55–16:05	Mislav Balokovich	*The NuSTAR Survey of Swift/BAT AGN as a Probe of the Unified Model*
16:10–16:20	Yuichi Terashima	*X–ray Light Curve Simulations of Clumpy–Torus Models*
16:25–16:35	Murray Brightman	*Determining the torus covering factor in Compton–thick AGN with NuSTAR*
Session V: 16:40–17:30		
Facilitated discussions on orientation as a driver for AGN unification		
Facilitators: Elizabeth Rivers, Chris Packham		
"Winchester Pub Crawl": 18:00		

Monday 14th – POSTER SESSION	
Time	Speaker
Andrew Robinson	*O1: Reverberation mapping the torus in 12 Active Galactic Nuclei using Spitzer and optical light curves*
Dinalva Sales	*O2: A Multiwavelength Study of the OH Megamaser Galaxy IRAS16399–0937*
Elizabeth Rivers	*O3: Investigating Dueling Scenarios in NGC 7582 with Broadband X–ray Spectroscopy*
Ismael Garcia–Bernete	*O4: The nuclear and extended infrared emission of the Seyfert galaxy NGC 2992*
Jiri Svoboda	*O5: X–ray variability of a polar–scattered Seyfert 1 galaxy Fairall51*
Kohei Ichikawa	*O6: Torus Geometry Difference between Hidden and Non–hidden Broad Line Active Galactic Nuclei*
Marko Stalevski	*O7: AGN dust covering factors: What's wrong and how to fix them*
Paula Sanchez	*O8: NIR Variability of obscured and unobscured X–ray sources in the COSMOS field*
Pece Podigachoski	*O9: The Unification of Powerful Quasars and Radio Galaxies*
Suk Yee Yong	*O10: The Disk Wind Model and the Effect on the Virial Black Hole Mass Estimation*
Victor Oknyansky	*O11: The relative wavelength independence of IR lags in AGNs: implications for the distribution of the hot dust*

Tuesday 15th – ACCRETION		
Time	Speaker	Topic
Session I: 8:50-10:10		
Chair: Nancy Levenson		
8:50–9:05	Ari Laor	*The Effect of Radiation Pressure on Photoionized Plasma*
9:10–9:25	Moshe Elitzur	*Structure and Evolution of the AGN torus and broad lines region*
9:30–9:45	Marc Schartmann	*Radiation pressure driven obscuring dust structures*
9:50–10:05	Chi Ho (Edwin) Chan	*Self–consistent radiative hydrodynamic simulations of dusty AGN torus*
Coffee: 10:10-10:40		
Session II: 10:40-11:50		
Chair: Nancy Levenson		
10:40–10:55	Andrew King	*Feeding, Feedback and the AGN Environment*
11:00–11:15	Alexei Baskin	*What sets the covering factor of the BLR and the torus?*
11:20–11:30	James Matthews	*Modelling the Spectra of Quasars: Clumpy Winds and Unification*
11:35–11:45	Dominique Sluse	*What can we learn about quasars and unification scheme with the microlensing technique*
11:50–11:55		*Flash Discussion*
LUNCH: 11:55-13:20		
Session III: 13:20-14:45		
Chair: Jörg–Uwe Pott		
13:20–13:40	**Poster Presentations**	*1–min talks + brief Q&A on posters*
13:40–13:55	Stephanie Lamassa	*The Changing Looks of AGN*
14:00–14:10	Jessie Runnoe	*Changing–Look Active Galactic Nuclei With The Time Domain Spectroscopic Survey (TDSS)*
14:15–14:25	Margherita Giustini	*Witnessing matter accreting onto the central Supermassive Black Hole of NGC 2617*
14:30–14:45	Jane Turner	*X–ray reprocessing in local AGNs*
Coffee: 14:50-15:20		
Session IV: 15:20-16:50		
Chair: Jörg–Uwe Pott		
15:20–15:35	Belinda Wilkes	*High levels of obscuration in orientation–unbiased, radio–selected (3CR), high luminosity AGN*
15:40–15:50	Claudio Ricci	*Obscuration properties of hard X–ray selected AGN*
15:55–16:10	Daniel Asmus	*Do low–luminosity AGN differ? —- The mid–infrared perspective*
16:15–16:30	Taiki Kawamuro	*Study of torus structure of low–luminosity active galactic nuclei with Suzaku*
Session V: 16:35–17:20		
Facilitated discussions on accretion as a driver for AGN unification		
Facilitators: Elizabeth Rivers, Chris Packham		
Free Evening and Public Outreach Event: 18:30 & 19:20		

Tuesday 15th – POSTER SESSION	
Time	Speaker
Johannes Buchner	*A1: Constraints on the torus geometry from X–ray population studies*
Lorena Hernandez Garcia	*A2: On the variable nature of low luminosity AGN*
Masa Imanishi	*A3: ALMA observations of molecular gas in the close vicinity of AGNs*
Miguel Pereira Santaella	*A4: NGC1614. Nuclear star–formation or an X–ray weak AGN?*
Nicholas Higginbottom	*A5: Radiation–hydrodynamic simulations of quasar disk winds*
Sam Connolly	*A6: Unification of Low Luminosity AGN and Hard State X–ray Binaries*
Sam Mangham	*A7: Reverberation Mapping of Accretion Disk Winds in Active Galactic Nuclei*
Stéphane Paltani	*A8: REFLEX: A versatile MC code to study X–ray reflexion around AGN*
Tiago Vecchi Ricci	*A9: IFU Spectroscopy of 10 ETG nuclei: Properties of the circumnuclear gas emission*
Tobias Beuchert	*A10: A Variable–Density Absorption Event in NGC 3227 mapped with Suzaku and Swift*

Wednesday 16th – EVOLUTION		
Time	Speaker	Topic
Session I: 8:50-10:10		
Chair: Miguel Pereira Santaella		
8:50–9:05	Hagai Netzer	*Unification and/or evolution?*
9:10–9:25	Yoshihiro Ueda	*Cosmological Evolution of X–ray Selected AGNs and Synthesis of the X–ray Background*
9:30–9:45	Santiago Garcia–Burillo	*Molecular line emission in NGC1068 imaged with ALMA*
9:50–10:05	Almudena Alonso Herrero	*Peering through the nuclear dust of ULIRGs and quasars in the local universe with GTC/CanariCam*
Coffee: 10:10-10:40		
Session II: 10:40-11:55		
Chair: Miguel Pereira Santaella		
10:40–10:55	Beatriz Villarroel	*Probing AGN Unification with galaxy neighbours: pitfalls and prospects*
11:00–11:15	Antonis Georgakakis	*Observational constraints on the obscuration distribution of AGN to redshift z 5*
11:20–11:35	Deborah Dultzin	*Support for an Evolutionary Model of AGN*
11:40–11:50	Takuma Izumi	*Coevolution of supermassive black holes and circumnuclear dense molecular gas disks in Seyfert galaxies*
11:55–12:00		*Flash Discussion*
LUNCH: 12:00-13:30		
Session III: 13:30-15:00		
Chair: tbc		
13:30–13:50	**Poster Presentations**	*1–min talks + brief Q&A on posters*
13:50–14:10	Ric Davies	*An Observational Perspective on the Drivers of Torus Evolution*
14:10–14:20	Bernd Vollmer	*Properties and evolution of massive thick gas tori With The Time Domain Spectroscopic Survey (TDSS)*
14:25–14:40	Erin Hicks	*The Keck OSIRIS Nearby AGN Survey: The Nuclear Gas and Stellar Structure in the Central 200 pc of Seyfert Galaxies*
14:45-14:55		*CONFERENCE PHOTO*
Coffee: 15:00-15:30		
Session IV: 15:30-16:40		
Chair: tbc		
15:30–15:45	Dave Alexander	*Connections between AGN activity, star formation, and obscuration*
15:50–16:05	Judith Ineson	*Accretion modes, environments and fuelling of Radio–loud AGN*
16:10–16:20	Liam Coatman	*Black–hole masses, outflows and hot dust at high redshift*
16:25–16:35	Judit Garcia Gonzalez	*The nuclear and intergrated FIR emission of Seyfert galaxies*
Session V: 16:40–17:30		
Facilitated discussions on evolution as a driver for AGN unification		
Facilitators: Masa Imanishi, Francesco Shankar		
Conference Dinner at the Guildhall: 19:00		
"Torus vs. Wind" brawl by Nancy Levenson and Sebastian Hoenig		

Wednesday 16th – POSTER SESSION	
Time	Speaker
Andreea Petric	*E1: The Cold Dust Content of Broad and Narrow–Line Optically Luminous nearby QSO*
Chelsea MacLeod	*E2: A Systematic Search for Changing–Look Quasars in SDSS*
Damien Gratadour	*E3: An extended nuclear torus revealed in NGC 1068 thanks to polarimetric imaging at high angular resolution*
Davide Lena	*E4: Gas kinematics in the inner kiloparsec of NGC 1386: a new clue to the torus–galaxy connection?*
Fernando J. Romero–Cruz	*E5: Hyper massive black holes in evolved galaxies*
Jörg–Uwe Pott	*E6: Monitoring the temperature and reverberation delay of the circumnuclear hot dust in NGC 4151*
Mariana Lazarova	*E7: Low–z LoBAL QSOs: orientation or evolution?*
Takeo Minezaki	*E8: A New Black Hole Mass Estimate for Obscured Active Galactic Nuclei*
Volker Heesen	*E9: A low–frequency radio continuum study of the FRI radio galaxy 3C31 with LOFAR*

Thursday 17th – PAST, PRESENT, FUTURE		
Time	Speaker	Topic
Session I: 9:00-10:10Session I: 9:00-10:10		
Chair: Ian McHardy		
9:00–9:10	Martin Ward	*The Inner Region of the Torus*
9:15–9:25	Brad Peterson	*Comments on Dust Reverberation*
9:30–9:40	Christian Knigge	*Quasar Unification Via Disk Winds: From Phenomenology to Physics*
9:45–9:55	Anthony Readhead	*Key Radio Unification Steps Before 1980 and Some Related Recent Radio Observations*
Coffee: 10:00-10:25		
Session II: 10:25-11:25		
Chair: Ian McHardy		
10:25–10:40	Karina Caputi	*AGN studies with JWST/MIRI*
10:45–11:00	Stefan Kraus	*AGN science opportunities with the future PFI interferometer*
11:05–11:20	Hirofumi Noda	*Development of Instruments onboard ASTRO–H for Future X–ray Studies of Tori*
Session III: 11:25–12:20		
Conference summary and final discussions		
Facilitators: Andreea Petric, Marko Stalevski, Margherita Giustini		
Conference End		
Field trip: 13:20–22:00		

Monday 14 September: Orientation

3 Abstracts

3.1 Monday 14 September - Oral Presentations

Polarimetry on life support

Ski Antonucci
University of California Santa Barbara

Polarimetry helped to reveal the AGN 'tori' and scattering mirrors, and it's dismaying that the technique has been virtually abandoned. Some decisive information is available about the central engines of AGN and about the environments and formation of massive high redshift radio galaxies. Historical studies have only scratched the surface of what could be done.

Testing the unified model of AGN with broadband polarimetry

Frederic Marin
Astronomical Institute, CAS

The keystone of the unified model of AGN is the detection of optical broad line signatures in the polarized spectra of Seyfert-2s. Perpendicular scattering of BLR photons in the polar regions towards our line-of-sight naturally explains the anisotropic nature of AGN, likely to be due to equatorial obscuration. Hence, the observed AGN properties differ according to the orientation of the nuclear structure. However, the inclination of the system is not easily derived directly from observations, resulting in loose constraints, especially if estimated only from spectroscopic measurements. In this presentation, I will highlight the importance of polarimetric simulations in determining the true orientation of AGN by showing different realizations of the unified model. Predictions will be compared to a substantial catalog of optical-UV observations and extended towards the X-ray regime. The pre-selection by the ESA of a X-ray polarimeter for the study phase of the next M4 mission is a step forward in a better, broadband, understanding of AGN.

Upholding the Unified Model for Active Galactic Nuclei: VLT/FORS2 Spectropolarimetry of Seyfert 2 galaxies

Christina Ramos Almeida
IAC

The origin of the unification model for Active Galactic Nuclei (AGN) was the detection of broad hydrogen recombination lines in the optical polarized spectrum of the Seyfert 2 galaxy (Sy2) NGC1068. Since then, a search for the hidden broad-line region (HBLR) of nearby Sy2s started, but polarized broad lines have only been detected in 40% of the nearby Sy2s observed to date. Here we present new VLT/FORS2 optical spectropolarimetry of a sample of 15 Sy2s, including Compton-thin and Compton-thick sources. We report the detection, at the 3 sigma level, of a HBLR in all the galaxies but one, for which the broad component is detected at the 2 sigma level. The sample includes six galaxies without previously published spectropolarimetry, some of them normally treated as non-hidden BLR (NHBLR) objects in the literature, and four Sy2s classified as NHBLR based on previous spectropolarimetry data. Our results confirm that at least some NHBLRs were misclassified, bringing previous publications reporting differences between HBLR and NHBLR objects into question. We detect broad Ha and Hb components in polarized light for 13 targets, and just broad Ha in the other two. We do not find any correlation between the properties of the polarized spectra and the column densities measured from the X-rays or torus inclination, but a larger sample is required to confirm this lack of correlation.

The mid-IR and near-IR interferometry of AGNs: key results and their implications

Makoto Kishimoto
Kyoto Sangyo University

Infrared interferometry has been very productive in directly probing the structure of AGNs at sub-pc scales. With tens of objects already probed in the mid-IR and near-IR, I will summarize the key results and implications from this direct exploration. The Keck interferometry in the near-IR and VLTI in the mid-IR shaped the luminosity dependence of the torus size and structure, while the latter also revealed an equatorial structure at several Rsub (dust sublimation radius), and a polar-elongated region at a few tens of Rsub. Notably, this polar component seems to dominate the compact mid-IR flux. This component can persuasively be attributed to a polar outflow. However, interferometry, through emissivity estimations, also indicates that it is not a UV-optically-thin cloud but participating in the obscuration of the nucleus. I will discuss how to accommodate all these facts to build a consistent picture.

Disks and cones: resolving the dusty torus with mid-infrared interferometry.

Konrad Tristram
ESO

The thermal emission of dust is one of the main possibilities to study the (dusty) material of the so-called "torus" in AGN. Observations using interferometry in the mid-infrared have, in the last ten years, resolved and characterised this emission beyond simple fits of spectral energy distributions, leading to a great leap forward in our view of the dusty material surrounding AGN.

I will present the most recent results of such observations, obtained with the instrument MIDI. More than 25 active nuclei could be observed with MIDI, showing that the dust distributions are parsec sized. The sizes roughly scale with the square root of the luminosity, albeit with a much large scatter than in the near-infrared. Detailed studies of a few well resolved sources, among them the illustrious nuclei of NGC1068 and the Circinus galaxy, show a two component structure: an inner disk-like emission region which is surrounded by a polar elongated emitter. The latter shows differential absorption in line with the one-sided ionisation cones observed in the optical. These results are in qualitative agreement with recent hydrodynamic simulations of AGN tori. In general, they confirm the concept of a dusty obscurer providing viewing-angle dependent obscuration of the central engine.

Mid-infrared interferometry of AGNs: A statistical view into the dusty nuclear environment of the Seyfert Galaxies.

Noel Lopez Gonzaga
Leiden Observatory

The high resolution achieved by the instrument MIDI at the VLTI allowed to obtain more detail information about the geometry and structure of the nuclear mid-infrared emission of AGNs, but due to the lack of real images, the interpretation of the results is not an easy task. To profit more from the high resolution data, we developed a statistical tool that allows interpret these data using clumpy torus models. A statistical approach is needed to overcome effects such as, the randomness in the position of the clouds and the uncertainty of the true position angle on the sky. Our results, obtained by studying the mid-infrared emission at the highest resolution currently available, suggest that the dusty environment of Type I objects is formed by a lower number of clouds than Type II objects.

The physics of megamaser AGN

Alberto Masini
DIFA University of Bologna

Many local active galactic nuclei (AGN) show water vapor molecule maser emission at 22 GHz. Using Very Long Baseline Interferometry (VLBI) radio interferometry, this emission can be spatially mapped, showing in some sources a nearly edge-on, disk-like structure, in keplerian motion around a supermassive black hole (SMBH). Together with radio emission, hard X-rays are an important way to test and probe the physics of AGN, especially the most obscured ones. Very few local, VLBI-mapped, with high quality hard X-ray observations AGN are known today, but it is clear that disk megamasers are preferentially found in Compton thick (NH $> 1.5\times10^{24}$) Seyfert 2 (Sy2) AGN, hinting towards a connection between high obscuration and maser emission. We show that, using a well defined sample of 15 local Sy2 megamasers with both radio VLBI mapping and NuSTAR hard X-ray spectral coverage, a simple analytical model with spatial continuity and same density profile between the maser disk and the torus allows to recover obscuring column densities in parsec-scale tori in good agreement with the NuSTAR measurements. Moreover, we provide a simple geometrical interpretation for the rarity of maser disk emitting sources and their connection with high obscuring columns in Sy2 AGN, together with hints of a slightly different torus density profile between Compton thin and Compton thick sources.

Reverberation Measurements of the Inner Radius of the Dust Torus in 17 Seyfert Galaxies

Shintaro Koshida
NAOJ / Subaru Telescope

I present the results of a dust reverberation survey for 17 nearby Seyfert 1 galaxies in MAGNUM project, which provides the largest homogeneous collection of the innermost radii of dust tori. As a result of a cross-correlation function analysis and an alternative posterior probability distribution method, 49 measurements were obtained through the time lags between V and K band flux variations. The time lags we found to strongly correlated to the optical luminosity in the range of –16 to –22 mag in M_V with the regression line $logDeltat = -2.11 - 0.2M_V$, assuming $DeltatproptoL^{0.5}$ as theoretically expected. The intrinsic scatter of 0.13 dex can be counted partly by the variation of both internal extinction and delayed response of the time-lag variations against the optical flux variations. Any systematic correlation of the scatter was not found along the Seyfert type nor the Eddington ratio.

The correlation by dust reverberation was compared with that by the near-infrared interferometry and that by the reverberation mapping of broad Balmer emission lines. The interferometric radii were found to be systematically larger than the dust reverberation radii by a factor of two, which could be interpreted as the difference between the flux-weighted and the response-weighted radii. The reverberation radii of the broad lines were systematically smaller by a factor of four or five, which strongly supports the unified scheme on Seyfert type of active galactic nuclei. The radius–luminosity correlations for the hard X-ray (14–195 keV) and the [Oiv]$Lambda$25.89 mum emission-line luminosities are also presented.

Towards A Complete Census of the Compton-thick AGN population and the N_H Distribution of AGN in the Local Universe.

Ady Annuar
Durham University

We present updated results from an ongoing project to establish the most unbiased census of the Compton-thick active galactic nucleus (CTAGN) population and the intrinsic column density (N_H) distribution of the overall AGN population in the local universe, using a sample of mid-infrared (mid-IR) selected AGN within 15 Mpc. We find that 20% of the AGN in the sample are bona-fide CTAGN based upon hard X-ray studies ($E > 10$ keV). More candidates are then selected using multiwavelength techniques, i.e. mid-IR:X-ray and optical [OIII]λ5007Å:X-ray flux ratios. Based on these analyses along with evidence from previous literature, we initially find a further 25% of potential candidates. We then observed two of these candidates, NGC 5643 and NGC 3486, using NuSTAR and is able to confirm the former as a CTAGN and rule out the latter as an obscured AGN. This constrains the total CTAGN population in the sample to 25–40%, though it could potentially be as high as 65% accounting for those that still lack data. Finally, we use these results to estimate the intrinsic N_H distribution of the local AGN population. Two more of our CTAGN candidates are scheduled to be observed by NuSTAR, bringing the completeness of hard X-ray energy data of the sample to 65%. This work provides a well-defined local benchmark for AGN unification studies.

Modeling the Reverberation Response of the Dusty Torus Emission of NGC 6418

Triana Almeyda
Rochester Institute of Technology

According to unified models of active galactic nuclei (AGN), the supermassive black hole is surrounded by an obscuring circum-nuclear torus of dusty molecular gas. However, its size, composition, and structure are not well understood or strongly constrained by observations. We recently completed a 2.5 year monitoring campaign in the mid-infrared and optical bands using the Spitzer Space Telescope and several ground-based telescopes, with the aim of using the reverberation mapping technique to determine the "size" of the torus in 12 Type 1 AGN. As an interpretational tool, a computer simulation has been developed to model the response of the dust emission spectrum of the torus to changes in the AGN optical luminosity. Given an input light curve, the code computes the integrated emission of an ensemble of dust clouds as a function of time at selected wavelengths, taking into account light travel delays. Here we model the observed light curves of NGC 6418, exploring the effects of various properties (including the torus opening angle, inclination and radial depth, the dust composition, and anisotropy of the illuminating radiation field) on the torus response at different wavelengths.

Obscuration in active galactic nuclei: near-infrared luminosity relations and dust colors

Leonard Burtscher
MPE

We present an atlas of high resolution near-IR IFU observations of 51 local AGNs in which we disentangle the AGN and stellar emission using both spatial and spectral information. Using the derived near-IR dust luminosity and temperature as well as auxiliary data, we construct a new diagnostic plot. This plot of near-to-mid-IR color vs. near-IR temperature allows us to estimate the obscuration to the hot dust with a simple torus model whose parameters are in agreement with structural information derived from infrared interferometry of AGN tori. Additionally, we show high-resolution near-IR luminosity relations and find a clear distinction between type 1 and type 2 AGNs, if the AGN classification is based uniformly on high-resolution data.

NuSTAR: Probing the Geometry of Obscuration in the High Energy X-ray Band

Fiona Harrison
Caltech

NuSTAR is the first focusing telescope to operate in the high energy X-ray (3–79 keV). Using high quality measurements across a broad energy band NuSTAR probes the band where Compton reflection from dense material imprints distinctive features on the spectrum. Combined with timing information, this is providing measurements of the geometry and size scales of dense structures in the central regions of AGN. I will highlight results from the mission which have led to improved understanding of the structure of the torus, and the relation to unified models of AGN.

First X-ray Statistical Tests for Clumpy Torii Models: Constraints from RXTE monitoring of Seyfert AGN

Alex Markowitz
University of California San Diego

We summarize two papers providing the first X-ray–derived statistical constraints for both clumpy-torus model parameters and cloud ensemble properties.

In Markowitz, Krumpe, & Nikutta (2014), we explored multi-timescale variability in line-of-sight X-ray absorbing gas as a function of optical classification. We examined 55 Seyferts monitored with the Rossi X-ray Timing Explorer, and found in 8 objects a total of 12 eclipses, with durations between hours and years. Most clouds are commensurate with the outer portions of the BLR, or the inner regions of infrared-emitting dusty tori. The detection of eclipses in type Is disfavors sharp-edged tori. We provide probabilities to observe a source undergoing an absorption event for both type Is and IIs, yielding constraints in [N_0, sigma, i] parameter space.

In Nikutta et al., in prep., we infer that the small cloud angular sizes, as seen from the SMBH, imply the presence of $>10^7$ clouds in BLR+torus to explain observed covering factors. Cloud size is roughly proportional to distance from the SMBH, hinting at the formation processes (e.g. disk fragmentation). All observed clouds are sub-critical with respect to tidal disruption; self-gravity alone cannot contain them. External forces (e.g. magnetic fields, ambient pressure) are needed to contain them, or otherwise the clouds must be short-lived. Finally, we infer that the radial cloud density distribution behaves as $\sim 1/r^{0.7}$, compatible with VLTI observations.

Our results span both dusty and non-dusty clumpy media, and probe model parameter space complementary to that for short-term eclipses observed with XMM-Newton, Suzaku, and Chandra.

NuSTAR Survey of Swift/BAT AGN as a Probe of the Unified Model

Mislav Balokovich
Caltech

NuSTAR has enabled studies of the local AGN to extend into the spectral window above 10 keV with unprecedented spatial resolution and two orders of magnitude better sensitivity than any other instrument operating in that energy range. As a part of its long-term extragalactic program NuSTAR is surveying the nearby population of AGN detected at hard X-ray energies by the Swift/BAT instrument. We present results based on observations of ∼100 Swift/BAT-selected Type-2 Seyferts surveyed in the first three years of NuSTAR operation. This large sample forms an atlas of the highest quality hard X-ray spectra available to date. Assuming a range of hard X-ray spectral models, phenomenological as well as physically motivated, we constrain the main spectral parameters for each source individually and test the applicability of the models on a large sample for the first time. This analysis allows us to determine distributions of the main spectral parameters related to the torus, such as the absorption column, reflection strength, and iron line equivalent width, in a well-defined population of nearby obscured AGN. More advanced models for the AGN torus allow us to investigate differences between various subsamples and interpret them within the unified model paradigm. We will discuss the implications for the structure of the torus in the local population of Type-2 Seyferts and present a comprehensive comparison of constraints derived from X-ray data and constraints from observations at other wavelengths for a relatively large sample.

X-ray Light Curve Simulations for Clumpy-Torus Models

Yuichi Terashima
Ehime University

Many lines of evidence support the idea that the obscuring torus is composed of clumpy clouds rather than uniform matter. Measurements of X-ray absorption and its time variability provide us with constraints on the size and location of the clouds, in particular, if X-ray variability caused by single or a few absorbing clouds are observed ("occultation events"). We adopt the clumpy torus model used by Nenkova et al. (2008), in which power law and Gaussian distributions of the number of clouds per unit length are assumed in the radial direction and for the angle from the equator, respectively. We simulate the time dependence of X-ray absorption (number of clouds along the line of sight, absorption column density, covering fraction of the nuclear X-ray source), and then calculate X-ray light curves and their power spectral densities. The dependence on various parameters (size and location of clouds, central black hole mass, inclination angle etc.) are explored. Among them, key parameters are the number of clouds and crossing time across the line of sight, the locations of the clouds that determine orbit time scale. If the number of clouds along sight line is large enough ($\gg 10$), the covering fraction is almost always unity and the variability of absorption column is mild. On the other hand, if much fewer clouds exist, we expect more probability to find "occultation events" which provide strong constraints on cloud parameters.

Determining the torus covering factor in Compton-thick AGN with NuSTAR

Murray Brightman
Caltech

The covering factor of Compton-thick (CT) obscuring material associated with the torus in active galactic nuclei (AGNs) is at present best understood through the fraction of sources exhibiting CT absorption along the line of sight (NH $> 1.5 \times 10^{24}$ cm^{-2}) in the X-ray band, which reveals the average covering factor. Determining this CT fraction is difficult, however, due to the extreme obscuration. With its spectral coverage at >10 keV, NuSTAR is sensitive to the covering factor since Compton scattering of X-rays off optically thick material dominates at these energies. I will present results on a spectral analysis of 10 CTAGN observed with NuSTAR where we have used the torus models of Brightman

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3.2 Monday 14 September - Poster Presentations

O1: Reverberation mapping the torus in 12 Active Galactic Nuclei using Spitzer and optical light curves

Andrew Robinson
Rochester Institute of Technology

We present results from a ∼2.5 year monitoring campaign using the Spitzer Space Telescope during its "warm" mission. 12 low-redshift broad-line AGN were observed at 3.6 and 4.5 microns, with a 3 day cadence during the first 17 months and a 30 day cadence for the remaining 12 months. Contemporaneous optical observations were also obtained from several ground-based telescopes. Significant IR variability was observed in 11 of the 12 objects, with typical timescales ∼100 days and relative amplitudes ranging from ∼10% to ∼100%. We present cross-correlation analyses of the IR and optical light curves for the sample as a whole and discuss in detail the case of NGC6418, which exhibits the largest variability amplitude. In this object, the IR-optical lag implies that the dust emitting at 3.6 and 4.5 microns is located at a distance 1 light-month from the source of the AGN UV–optical continuum. This is consistent with the inferred lower limit to the sublimation radius for pure graphite grains at 1800 K, but smaller by a factor of ∼2 than the corresponding lower limit for a "standard" ISM dust composition.

O2: A Multiwavelength Study of the OH Megamaser Galaxy IRAS16399-0937

Dinalva Sales
Rochester Institute of Technology

We present a multiwavelength study of the morphology and spectral energy distribution (SED) of the OH Megamaser galaxy (OHMG) IRAS16399- 0937, based on new HST ACS broad band (F814W) and emission line (Hα+[NII]) images and archive data from HST, 2MASS, Spitzer, Herschel and the VLA (Fig. 1). This system has a double nucleus, whose northern (IRAS16399N) and southern (IRAS16399S) components have a projected separation of $\sim$ 6" (3.4 kpc) and have previously been optically identified as a Low Ionization Nuclear Emission Line Region (LINER) and Starburst (SB) nucleus, respectively. The nuclei are embedded in a tidally distorted common envelope, in which star formation activity is widespread, but mostly heavily obscured (Fig. 1). The infrared spectrum is dominated by strong polycyclic aromatic hydrocarbon (PAH) features, but deep silicate absorption and absorption features due to water ice and hydrogenated amorphous carbon grains are also present, and are strongest in the IRAS16399N nucleus (Fig. 2 and 3). The radio emission, including the compact component associated with the IRAS16399N nucleus, is generally consistent with star formation. The global star formation rate (SFR) is $\sim$20M$_\odot$/yr, with the two nuclei accounting for $\sim$40% of the total (Table 2). The 0.435 - 500μm SED was fitted with a model including stellar, dusty+PAH ISM and AGN torus components using our new Markov Chain Monte Carlo code, clumpyDREAM (Fig. 4). The results indicate that the IRAS16399N nucleus contains an AGN of bolometric luminosity (Lbol $\sim$ 10^{44} ergs/s), which is deeply embedded in a quasi-spherical distribution of optically thick clumps with a covering fraction $\sim$ 1 (Table 1). We suggest that these clumps are the source of the OH megamaser emission in IRAS16399-0937. The high torus covering fraction precludes AGN photoionization as the origin of the LINER spectrum, however, the spectrum is consistent with shocks of velocity $\sim$ 100 – 200 km/s. The SED fits indicate SFRs of $\sim$ 2.9 and 2.4 M$_\odot$/yr for the IRAS16399N and IRAS16399S nuclei, respectively, roughly consistent with the rates derived from the observed 8μm PAH and 1.49 GHz radio luminosities (Table 1 and 2). The low accretion rate and modest nuclear star formation rates suggest that while the gas-rich major merger forming the IRAS16399-0937 system has triggered widespread star formation, the massive gas inflows expected from merger simulations have not yet fully developed.

O3: Investigating Dueling Scenarios in NGC 7582 with Broadband X-ray Spectroscopy

Elizabeth Rivers
Caltech

NGC 7582 is a well-studied X-ray bright Seyfert 2 with moderately heavy ($N_H = 10^{23} - 10^{24}$ cm^{-2}), highly variable absorption and unusually strong reflection spectral features. The spectral shape changed around the year 2000, dropping in observed flux and becoming much more highly absorbed. Two scenarios have been put forth to explain this spectral change: 1) the source "shut off" around this time, decreasing in intrinsic luminosity, with a delayed decrease in reflection features due to the light crossing time of the Compton-thick material or 2) the source is a "hidden nucleus" which has recently become more heavily obscured, with only a portion of the power law continuum leaking through. NuSTAR observed NGC 7582 twice in 2012 two weeks apart in order to quantify the reflection using high-quality data above 10 keV. We analyze both NuSTAR observations placing them in the context of historical X-ray, infrared and optical observations, including re-analysis of RXTE data from 2003-2005. We find that the most plausible scenario is that NGC 7582 has a hidden nucleus which has recently become more heavily absorbed by a patchy torus with a covering fraction of 80-90% and a column density of 3.6 x 10^{24} cm^{-2}. We find the need for an additional highly variable full-covering absorber with N_H= 4-6 x 10^{23} cm^{-2}, possibly associated with a hidden broad line region or a dust lane in the host galaxy.

O4: The nuclear and extended infrared emission of the Seyfert galaxy NGC 2992

Ismael Garcia-Bernete
IAC

Observations in the mid-infrared (MIR) are key to study the nuclear and circumnuclear emission of active galaxies. We present subarcsecond resolution IR imaging and MIR spectroscopic observations of the Seyfert 1.9 galaxy NGC 2992, taken with 8-10m-class ground-based telescopes. Using arcsecond resolution MIR and far-IR imaging, we obtained nuclear fluxes using different methods and we find that we can only recover the nuclear fluxes obtained from the subarcsecond data at 20-25 micron, where the AGN emission dominates. We fitted the high angular resolution nuclear IR spectral energy distribution (SED) of NGC 2992 with clumpy torus models, and then used the best-fitting model to decompose the Spitzer/IRS 5-30 spectrum (630 pc) in AGN and starburst components. We find that the AGN component peak at 20 microns, which is agreement with the photometry results. This study is part of a large program aimed to obtain two complete catalogues of subarcsecond resolution MIR observations of nearby Seyfert galaxies. Combining the high angular resolution MIR observations and Spitzer/IRS spectra available, we will characterize the nuclear and extended emission of the galaxies in this range. The MIR emission of the galaxies will then be compared with different AGN tracers to assess the importance of the AGN contribution to the MIR emission on pc and kpc scales. This analysis will provide statistically significant results for two different samples selected in different ways.

O5: X-ray variability of a polar-scattered Seyfert 1 galaxy Fairall 51

Jiri Svoboda
Astronomical Institute, CAS

Polar-scattered Seyfert 1 galaxies are characterised by an unusually large optical polarisation for the type-1 objects. Therefore, they are believed to represent a bridge between unobscured Type-1 and obscured Type-2 objects. Their X-ray spectra show complex and variable X-ray absorption. I will present our recent results on the Suzaku X-ray monitoring of Fairall 51, whose intrinsic spectrum is affected by at least three absorbers with different ionisations. We found that the least ionised absorber is variable on a week-long scale, from which we constrained the location in the Broad Line Region (BLR). Assuming an intermediate inclination of the source, this implies that the BLR clouds can reach relatively high altitudes above the equatorial plane.

O6: Torus Geometry Difference between Hidden and Non-hidden Broad Line Active Galactic Nuclei

Kohei Ichikawa
NAOJ

We present results from the fitting of infrared (IR) spectral energy distributions of 21 active galactic nuclei (AGNs) with clumpy torus models. We compiled high spatial resolution (∼0.3–0.7 arcsec) mid-IR (MIR) N-band spectroscopy, Q-band imaging, and nuclear near- and MIR photometry from the literature. Combining these nuclear near- and MIR observations, far-IR photometry, and clumpy torus models enables us to put constraints on the torus properties and geometry. We divide the sample into three types according to the broad line region (BLR) properties: type-1s, type-2s with scattered or hidden broad line region (HBLR) previously observed, and type-2s without any published HBLR signature (NHBLR). We find that NHBLR AGNs have smaller torus opening angles and larger covering factors than HBLR AGNs. This suggests that the chance to observe scattered (polarized) flux from the BLR in NHBLR could be reduced by the dual effects of (a) less scattering medium due to the reduced scattering volume given the small torus opening angle and (b) the increased torus obscuration between the observer and the scattering region. These effects give a reasonable explanation for the lack of observed HBLR in some type-2 AGNs.

O7: AGN dust covering factors: What's wrong and how to fix them.

Marko Stalevski
Universidad de Chile

The ratio of infrared (IR) and bolometric luminosity of active galactic nucleus (AGN) (L_{IR}/L_{AGN}) is commonly considered to be a proxy of the covering factor of the dusty material ('torus') surrounding the central engine. The dust covering factors obtained in such way are often used to infer fraction of obscured AGNs as a function of luminosity and redshift and thus have an important role in studying AGN evolution. We have investigated how reliable is L_{IR}/L_{AGN} ratio as an estimator of the dust covering factor. Making use of Monte Carlo radiative transfer simulations we calculated a grid of the dusty tori spectral energy distributions for a range of opening angles and other torus parameters. We compared the true, geometrical covering factors with the ones obtained from the luminosity ratios. From the analysis we found that relation between the covering factor and L_{IR}/L_{AGN} ratio is far from simple. Apart from well know difficulties for obtaining the correct bolometric luminosity of the accretion disk, the biggest obstacle comes from the fact that the deviation of L_{IR}/L_{AGN} from the true covering factor depends strongly and non-linearly on the covering factor itself. Based on our results, we offer a way to correct the observed L_{IR}/L_{AGN} to correspond more closely to the true dust covering factors and discuss implications for inferring fraction of obscured AGNs as a function of luminosity.

O8: NIR Variability of obscured and unobscured X-ray sources in the COSMOS field

Paula Sanchez
Universidad de Chile

AGNs are characterized by their time-variable continuum flux in every waveband in which they have been studied. However very little is known about their variability in the infrared. This waveband gives us information about the dust surrounding the accretion disk at low redshift, and about the accretion disk at high redshift. In this work, I present our statistical study of the NIR variability of AGNs in the COSMOS field, using UltraVISTA data. This dataset give us a huge sample of light curves, making possible to have a global description of the nature of AGNs for different ranges of redshift, and for different levels of obscuration, from which we can have a better understanding of the difference between type 1 and type 2 AGNs.

O9: The Unification of Powerful Quasars and Radio Galaxies

Pece Podigachoski
Kapteyn Astronomical Institute

The unification model for powerful radio galaxies (RGs) and radio-loud quasars postulates that these objects are intrinsically the same but viewed along different angles. Herschel Space Observatory data permit the assessment of that model in the far-infrared spectral window. We analyze photometry from Spitzer and Herschel for the distant 3CR hosts, and find that RGs and quasars have different mid-infrared, but indistinguishable far-infrared colors. Both these properties, the former being orientation dependent and the latter orientation invariant, are in line with expectations from the unification model. Adding powerful radio-quiet active galaxies and typical massive star-forming (SF) galaxies to the analysis, we demonstrate that infrared colors not only provide an orientation indicator, but can also distinguish active from SF galaxies.

O10: The Disk Wind Model and the Effect on the Virial Black Hole Mass Estimation

Suk Yee Yong
University of Melbourne

The current 'standard quasar model' consists of a central engine, accretion disk, and jet. However, these components cannot entirely explain some quasar spectral features, specifically, the presence of broad emission lines (BELs), which are assumed to originate from high velocity gas in the broad line region (BLR). The addition of a wind to the standard model provides a mechanism to drive the outflowing gas emanated from the accretion disk.

The shape of the emission line profiles in the BLR, in particular, the velocity offsets and skewness for different viewing angles, are explored. The impact on the virial black hole mass calculation due to the quasar's orientation to the observer is also tested. The geometry of the BLR is modelled by implementing the wind component or the disk wind model. While the models are dependent on the specified parameters, they are able to qualitatively reproduce the predicted features of the emission lines.

O11: The relative wavelength independence of IR lags in AGNs: implications for the distribution of the hot dust

Victor Oknyansky
Sternberg Astronomical Institute, Moscow M.V. Lomonosov State University

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As seen from the central source, the dusty torus of AGNs has a puzzlingly high covering factor. If the torus consists of clouds of dust, each with a relatively unobscured view of the higher energy photons from nearer the center of the AGN, the temperature of each dust cloud will fall off as roughly the inverse square root of the radius. Since the dust is heated by the central radiation, in such a model the Near and Mid IR lag would increase with the wavelength to a power of 2 to 2.8. We show that, contrary to this simple prediction, for a significant fraction of AGNs the lags of the J, H, K, and L bands with respect to the optical show at best only a small difference. This means that rather than there being an extended radial temperature gradient, the hot dust reprocessing the central radiation is effectively in a relatively thin shell. We show that this can be explained by the hot dust being on the surface of a cone that is approximately tangential to the paraboloidal isodelay surface.
We note that a number of the AGNs showing similar J, H, K, and L lags are also Seyferts that have changed between type 1 and type 2. It is not clear whether this is related or is merely a consequence of these objects being well studied for a long time.

Tuesday 15 September: Accretion

3.3 Tuesday 15 September - Oral Presentations

The Effect of Radiation Pressure on Photoionized Plasma

Ari Laor
Technion

Photoionization models calculate the energy transfer from the ionizing radiation to the gas. The associated momentum transfer is not always included. This radiation pressure sets the density structure within the photoionized gas, in particular if the gas is not radially accelerating. I will present the results of such calculations for photoionized gas in AGN, which provide a simple explanation for a range of the observed properties.

Structure and Evolution of the AGN torus and broad lines region

Moshe Elitzur
University of Kentucky

The structure of the AGN environment must evolve as the accretion rate is decreasing – obviously the AGN disappears altogether once the accretion rate drops to zero. The issue, then, is whether the evolution induced by the decline of accretion rate produces discernible effects before that final point is reached; that would imply that all AGN are not intrinsically the same. In this talk I will discuss evolutionary consequences within the disk-wind scenario for the AGN sub-pc region.

Radiation pressure driven obscuring dust structures

Marc Schartmann
Swinburne University of Technology

In this talk, a summary of the simulations presented in Wada et al. 2012 will be given, where the geometrical thickness of obscuring gas and dust structures in nearby Seyfert galaxies is understood in terms of a radiation pressure driven fountain process.
I will present time-resolved images and spectral energy distributions (SEDs) derived with 3D dust continuum radiative transfer simulations. When comparing the results to high spatial resolution SEDs as well as observed relations for nearby Seyfert galaxies, we find that a model which comprises of a clear three-component structure gives the best comparison with the data: a thin disc with spiral and filamentary high density features, a surrounding fluffy component (the obscurer) and a low density outflow along the rotation axis. Strong morphological differences are found depending on wavelength: whereas the mid-infrared images are dominated by the elongated appearance of the outflow cone (reminiscent of recent interferometric observations), the long wavelength emission is mainly given by the cold and dense disc component.

Self-consistent radiative hydrodynamic simulations of dusty AGN torus

Chi Ho Chan
Johns Hopkins University

We present the first self-consistent radiative hydrodynamic simulations of a dusty AGN torus subject to point-source UV and diffuse IR radiative acceleration. The simulations are conducted using the finite-volume hydrodynamics code Athena complemented by a module which solves the multi-angle group time-dependent radiative transfer equation directly. Our results have implications for torus covering fraction, IR anisotropy, mass inflow through the torus, as well as mass outflow in the form of UV-launched winds.

Feeding, Feedback and the AGN Environment

Andrew King
University of Leicester

AGN affect their surroundings via gravity, direct radiation, and mechanical feedback. I discuss some of the implications for a physical picture of the AGN environment.

What sets the covering factor of the BLR and the torus?

Alexei Baskin
Technion

There are accumulating observational evidence that place the BLR gas just inside the inner radius of the dusty torus. This was predicted more than 20 years ago based on theoretical considerations, which suggested that the BLR gas is just the inflowing dusty gas of the torus that passed the dust sublimation radius. The remaining open question is what mechanism sets the covering factor of the BLR and the torus. Recently, it was proposed that the BLR emission originates in a failed dusty wind which is driven vertically by radiation pressure on dust. The wind is launched from the accretion disc, just inward of the dusty torus, where the disc temperature is below the dust sublimation temperature. As the outflowing dusty gas elevates above the disc, it becomes exposed to the central continuum source and the dust sublimates, allowing the gas to produce BLR line emission. The dust sublimation terminates the vertical acceleration force, which sets the maximum height above the accretion disc that is reached by the failed wind, and thus its covering factor. I will present the result of detailed calculations of this model. I will discuss the implied dependence of the BLR and torus covering factor on different physical parameters.

Modelling the Spectra of Quasars: Clumpy Winds and Unification

James Matthews
University of Southampton

Blue shifted broad absorption lines (BALs) in the ultraviolet (UV) are seen in approximately 20% of quasi-stellar objects (QSOs), providing clear evidence that mass-loaded outflows are present in such systems (known as BALQSOs). These outflows may take the form of winds emanating from the accretion disk, and provide potential for a feedback mechanism with the host galaxy. Disk winds are also important in unification scenarios for QSOs and active galactic nuclei (AGN). We present Monte Carlo radiative transfer simulations using a simple biconical disk wind model which has already successfully reproduced BAL profiles. Previous models exhibited a well-documented 'over-ionization problem- it is difficult to maintain an ionization state which produces significant line opacity in UV resonance species such as CIV, while remaining consistent with observed X-ray luminosities of QSOs. We attempt to address this problem by examining the effect of clumping on the ionization state and inferred X-ray properties. We find that clumping allows for realistic X-ray properties compared to QSO/AGN samples and also produces significant broad emission lines at low inclinations. Our work suggests that such a disk wind geometry is a promising candidate for a unified model.

What can we learn about quasars and unification scheme with the microlensing technique ?

Dominique Sluse
University of Liege

Our understanding of the gravitational lensing phenomenon has deeply progressed since the discovery of the"first" gravitationally lensed object in 1979 by Walsh and collaborators. With more than hundreds of quasars known to be multiply imaged by a foreground galaxy, gravitational lensing is now a powerful astrophysical and cosmological tool. The stars located in lensing galaxies produce small deflections of the light rays coming from distant quasars which adds to the main deflection from the lensing galaxy. Because the deflection caused by the stars is small, the micro-images they produce remain unresolved. Only a flickering of the flux and spectral deformation of lensed quasars images are observed. I will explain how this micro-lensing effect, can be used to study the inner region of distant quasars. Specifically, I will zoom out from the inner accretion disc up to the torus, and give an overview of the information which can be retrieved at each of these scales. I will give a special emphasis on the constraint we can put on the orientation/geometry of the various emitting regions (i.e. disc, broad line region, torus) at each of these scales.

The Changing Looks of AGN

Stephanie LaMassa
Yale

According to the AGN unification model, the difference between Type 1 and Type 2 AGN is explained by the orientation of a circumnuclear obscuring torus to the observer's line of sight. Observations of seemingly anomalous sources challenge this theory. A handful of AGN have been discovered which have transitioned from Type 1, with strong, prominent broad-emission lines, to Type 1.8 or 1.9, with weak broad components to only H-alpha and/or H-beta, or vice versa. The rate of discovery of these objects has increased this past year thanks to the Sloan Digital Sky Survey BOSS and TDSS surveys which have repeated spectroscopic observations of AGN. While in some cases this transition can be explained by circumnuclear clouds eclipsing the broad line region, it seems clear that stochastic accretion is responsible for other changing-look AGN. In this talk, I will discuss the changing-look AGN discovered thus far and the implications these objects have for AGN unification and the intermittency of AGN activity.

Changing-Look Active Galactic Nuclei With The Time Domain Spectroscopic Survey (TDSS)

Jessie Runnoe
The Pennsylvania State University

Changing-look active galactic nuclei (CL-AGNs) present a unique opportunity to study AGN unification and physics. They are observed to transformation between the Type 1 and 2 classifications, supporting a picture in which both orientation to the observer and intrinsic spectral and luminosity evolution can play important roles in unification. In the same spirit, CL-AGNs also offer a way to study behavior brought about by abrupt changes in the accretion rate and may represent a previously unappreciated mode of quasar variability: prolonged "on-" and "off-states". CL-AGNs are uncommon, with only a handful identified to date, but several have been discovered in the Time Domain Spectroscopic Survey (TDSS), and these are likely just the tip of the iceberg. The TDSS offers a promising way of discovering substantial numbers of CL-AGN because it will revisit several thousand objects with previous spectra from the SDSS, many of which are selected based on substantial photometric variability. A statistical sample of these objects will allow us to move beyond the detailed case studies and start to understand the underlying physical mechanisms responsible for these dramatic spectral changes. I will describe our systematic search for CL-AGN in the TDSS and discuss what we have learned from a growing sample of these objects.

Witnessing matter accreting onto the central Supermassive Black Hole of NGC 2617

Margherita Giustini
SRON

The AGN in NGC 2617 underwent a strong outburst during 2013/14, concurrently switching from being a Seyfert 1.8 to be a Seyfert 1 sometimes during the past 10 years. Our two follow-up XMM-Newton observations revealed the source to look like a bare Seyfert 1 in X-rays, with the addition of the detection of persistent Fe K absorption redshifted by ∼30,000 km/s. We discuss possible origins for this intriguing phenomenon in the context of both accretion and evolution of AGN and the standard torus paradigm within the unification scenario.

X-ray reprocessing in local AGN

Jane Turner
University of Maryland Baltimore County

Feature-rich X-ray spectra of local AGN reveal signatures from circumnuclear reprocessing gas spanning a wide range of column density and ionization state; this gas is likely dominant in shaping X-ray spectra and variability in AGN. Combining spectral information with X-ray time lag signatures indicates that the nuclear regions have a high covering fraction outflow of absorbing, Compton-scattering gas existing on scales of light-hours. We have applied a Monte Carlo Radiative Transfer model to the local AGN population and found the X-ray properties can be explained simply by changing the observer's sightline through a Compton-thick cloud ensemble, although other important cloud dependences, such as column denisty or ionization state are not ruled out.

High levels of obscuration in orientation-unbiased, radio-selected (3CR), high luminosity AGN

Belinda Wilkes
Harvard University / Center for Astrophysics

Multi-wavelength studies of the low-frequency radio-selected, orientation unbiased, 3CR sample of luminous active galaxies (AGN) are able to address the critical problem of separating intrinsic physical from observed, orientation-dependent properties. Obscuration of the active nucleus is anisotropic and strongly frequency dependent leading to complex selection effects for observations in most other wavebands.

Recent Chandra, Spitzer, Herschel and multi-wavelength observations show that half the high-redshift ($1<z<2$) 3CR sub-sample is significantly obscured with ratios of unobscured:Compton thin ($22<\log N_H <24.2$): Compton thick(CT, $\log N_H > 24.2$) = 2.5:1.4:1. These ratios are consistent with expectations based on modeling the Cosmic X-ray Background. This 50% obscured fraction contrasts with typical estimates of 20% obscured from optically- and X-ray-selected high-luminosity samples. Expanding this study to lower redshift ($z>0.5$) 3CR sources confirms our initial results and reveals more complex X-ray spectra as the primary nuclear emission becomes more obscured. The apparent spectral slope or hardness no longer provides an estimate of the obscuration, and high signal-to-noise spectra are required to disentangle the multiple extended/scattered/reflected components. With the typical low S/N data of X-ray surveys, both the level of obscuration and the estimated instrinsic luminosities of highly-obscured AGN are likely to be significantly (*10-1000) underestimated, perhaps explaining the lower obscured fractions reported for optical- and X-ray-samples which have no independent measure of the AGN luminosity. Correcting for this effect would result in flatter derived luminosity functions and potentially change their deduced evolution.

Obscuration properties of hard X-ray selected AGN

Claudio Ricci
PUC Santiago

X-ray spectroscopy is a great tool to infer the characteristics of the circumnuclear material in AGN, which can be achieved by studying both absorbed and reprocessed X-ray radiation. Because of the limited effect of absorption, hard X-ray (>10 keV) selected samples of AGN are extremely well suited to study the characteristics and the evolution of the torus. In my talk I will report on the results obtained by studying the broad-band X-ray emission (0.3–150 keV) of the 830 AGN reported in the Swift/BAT 70 months catalog. Our work is to date the largest study of broad-band X-ray observations of AGN ever performed, and combines observations carried out by the major X-ray facilities of the past decade, for a total of more than 1,500 X-ray spectra. Our catalog is complemented by multi-wavelength data, spanning from radio to gamma-rays. In my presentation will focus on the evolution of the spectral and absorption properties of AGN, and discuss about the link between obscuration and the physical characteristics of the SMBH, such as Eddington ratio, luminosity and black hole mass.

Do low-luminosity AGN differ? – The mid-infrared perspective

Daniel Asmus
ESO

In this talk I will discuss the results of Asmus et al. (2011) about the mid-infrared (MIR) properties of nearby low-luminosity AGN and their relation to the nuclear hard X-ray properties. The focus will be on the question whether and how low-luminosity AGN differ from their more powerful counterparts, and in particular whether the dusty torus still exists in this regime. This question was addressed from the observational side with new high angular resolution (subarcsecond) MIR data. As one of the main diagnostics, the tight MIR–X-ray luminosity correlation present for all types of AGN can help to distinguish different scenarios for the nuclear structure at low luminosities. Specifically, star formation and radio jets as alternative sources of nuclear MIR emission are discussed. Furthermore, I investigate whether structural changes in the MIR are present with decreasing accretion rate and conclude with putting the low-luminosity AGN into a wider context with the other AGN types.

Study of torus structure of low-luminosity active galactic nuclei with Suzaku

Taiki Kawamuro
Kyoto University

We investigate the nature of the torus structure of eight low-luminosity active galactic nuclei (LLAGNs; NGC 1566, NGC 2655, NGC 3718, NGC 3998, NGC 4138, NGC 4941, NGC 5273 and NGC 5643) based on the broad band X-ray spectra (0.5-200 keV) obtained with Suzaku and Swift/BAT. Their X-ray luminosities are smaller than 1e 42 erg/s, while the Eddington ratios span a range from 1e-4 to 1e-2. No significant iron-K*alpha* line is detected in the spectra of two LLAGNs with the lowest Eddington ratios (<3e-4) in our sample (NGC 3718 and NGC 3998), suggesting that their tori are little developed. The others show the iron-K*alpha* equivalent widths larger than 100 eV. For these six LLAGNs, we utilize the Monte-Carlo based simulation code by Ikeda 09 to constrain the torus parameters by assuming a nearly spherical geometry. The torus solid-angles in three sources (NGC 2655, NGC 4138, and NGC 4941) are constrained to be $Omega/2pi > 0.34$, and the rest are found to have torus column-densities of $logN_{rmH} > 22.7$. These results suggest that there are two types of LLAGNs, (1) those where the torus is very small and little mass accretion takes place, and (2) those where the torus is moderately developed and a sufficient amount of gas is supplied to the black hole.

3.4 Tuesday 15 September - Poster Presentations

A1: Constraints on the torus geometry from X-ray population studies

Johannes Buchner
PUC & MPE

Within the framework of torus geometries, the covering fractions of material of various densities corresponds to the fraction of Compton-thin and Compton-Thick (CT) obscured AGN in the population. One way to constrain the obscurer geometry is thus to study the joint luminosity function and column density distribution of the AGN population.

I have recently provided a robust and non-parametric estimate of the distribution of X-ray selected AGN in obscuration as a function of redshift (Buchner et al. 2015). I will present the comparison of these results to recent hydrodynamical simulations and discuss the implications on the torus structure.

I will briefly review the luminosity-dependence of the obscurer as observed in surveys. Newest results indicate a redshift evolution and a potential dependence on Eddington ratio and black hole mass. This puts constraints on the origin and scale of the obscuring material, including contribution from gas and dust clouds on kpc-scales associated with the host galaxy. It also constrains proposed mechanisms for creation and maintenance of the torus.

A2: On the variable nature of low luminosity AGN

Lorena Hernandez Garcia
IAA

X-ray variability is very common in active galactic nuclei (AGN), but it is still unknown if these variations occur similarly in different families of AGN. The main purpose of this work is to disentangle the true structure of low ionization nuclear emission line regions (LINERs) compared to Seyfert 2s by the study of their X-ray variations. We assembled the X-ray spectral properties, as well as the X-ray variability pattern(s), which were obtained from simultaneous spectral fittings and letting different parameters to vary in the model, derived from our previous analyses (HernÃ¡ndez- GarcÃa et al. 2013, 2014, 2015). We find that Seyfert 2s need more complex models to fit their spectra than LINERs. Among the spectral parameters, major differences are observed in the soft (0.5–2 keV) and hard (2–10 keV) X-ray luminosities, and the Eddington ratios, which are higher in Seyfert 2s. Differences are observed also in the hard column densities, temperatures, and black hole masses, although less significant. Short-term X-ray variations cannot be claimed, while long-term variability is very common in both families. An exception is found for Compton-thick sources, which do not vary, most probably because the AGN is not accesible in the 0.5–10 keV energy band. The changes are mostly related with variations in the nuclear continuum, but other patterns of variability show that variations in the absorbers (more common in Seyfert 2s) and at soft energies can be present in a few cases. Variations at UV frequencies are observed only in LINER nuclei. The X-ray variations occur similarly in LINERs and Seyfert 2s, i.e., they are related to the nuclear continuum, although they might have different accretion mechanisms, being more efficient in Seyfert 2s. Absorption variations and changing-look sources are not usually observed in LINERs. However, UV nuclear variations are common among LINERs, indicating an unobstructed view of the inner disc where the UV emission might take place. We suggest that this might indicate the disappeareance of the broad line region and the torus in at least some LINERs.

A3: ALMA observations of molecular gas in the close vicinity of AGNs

Masa Imanishi
NAOJ / Subaru Telescope

Molecular line flux ratios in the (sub)millimeter wavelength range can be a powerful tool to probe obscured AGNs in dusty galaxies, because of negligible effects of dust extinction. We present the results of our ALMA Cycle 2 high-spatial-resolution (0.5") observations of the AGN-starburst composite galaxy, IRAS 20551-4250, using dense gas tracers, HCN/HCO /HNC J=3-2 and J=4-3 lines. It was widely assumed that molecular gas excitation in galaxies is dominated by collision. However, another important mechanism, infrared radiative pumping, has recently been paid attention, particularly in the close vicinity of an AGN, but its actual role is still unclear quantitatively. We found the following main results. (1) We detected vibrationally-excited (v2=1f) HCN/HNC J=3-2 and J=4-3 emission lines. Comparison with an infrared radiative pumping model suggests an HCN abundance enhancement in this obscured AGN. (2) Based on the derived vibrational excitation temperature, it is quantitatively demonstrated that infrared radiative pumping is significantly at work at least for HCN and HNC (and possibly for HCO as well). Understanding the infrared radiative pumping mechanism is therefore of fundamental importance to understand molecular gas excitation and molecular line flux ratios in the close vicinity of an AGN (Imanishi & Nakanishi 2013 AJ 146 91; Imanishi+15 ApJ submitted).

A4: NGC1614. Nuclear star-formation or an X-ray weak AGN?

Miguel Pereira Santaella
Centro de Astrobiologia (CSIC)

NGC1614 is one of the most luminous galaxies in the nearby Universe. It an ongoing minor merger hosting an extremely bright star-forming circumnuclear ring (diameter 600 pc, SFR$\sim$40 $M_\odot$/yr). The nature of the nuclear (central 150 pc) activity is unclear, although, so far, there is no evidence of an AGN.
Here we present new sub-arcsec mid-IR GTC/CanariCam imaging and spectroscopy of this object, which in combination with previous data, allowed us to constrain the properties of a possible AGN (or nuclear star-formation) as first step towards understanding the physical conditions and evolutionary state of the central kpc of NGC1614.

A5: Radiation-hydrodynamic simulations of quasar disk winds

Nicholas Higginbottom
University of Southampton

Disk winds are a compelling candidate to provide geometrical unification between Broad Absorption Line QSOs (BALQSOs) and Type1 Quasars. However, the geometry of these winds, and even the driving mechanism remain largely unknown. Progress has been made through RT simulations and theoretical analysis of simplified wind geometries but there are several outstanding issues including the problem of shielding the low ionization BAL gas from the intense X-ray radiation from the central corona, and also how to produce the strong emission lines which exemplify Type 1 Quasars. A complex, clumpy geometry may provide a solution, and a full hydrodynamic model in which such structure may well spontaneously develop is something we wish to investigate. We have already demonstrated that the previous generation of hydrodynamic models of BALQSOs suffer from the fact that radiation transfer (RT) was necessarily simplified to permit computation, thereby neglecting the effects of multiple scattering and reprocessing of photons within the wind (potentially very important processes). We have therefore embarked upon a project to marry together a RT code with a hydrodynamics code to permit full radiation hydrodynamics simulations to be carried out on QSO disk winds. Here we present details of the project and results to date.

A6: Unification of Low Luminosity AGN and Hard State X-ray Binaries

Sam Connolly
University of Southampton

We present X-ray spectral variability of four low accretion rate and low luminosity AGN (LLAGN)- M81, NGC 1097, NGC 1052 and NGC 3998 - as observed by Swift and RXTE. All four objects were selected due to having spectra which hardened with increasing count rate, converse to the 'softer when brighter' behaviour normally observed in AGN with higher accretion rates. The spectra were summed in flux bins and fitted with a variety of models. A simple absorbed power law model was found to fit the spectra of M81, NGC 1097 and NGC 3998 well, whilst NGC 1052 required a partially covered power law model. In all four cases, the most likely cause of spectral variability is found to be hardening of the photon index of the power law component with increasing luminosity. Such a correlation has been seen previously within samples of low accretion rate AGN but in only one case has it been seen within observations of a single AGN. Here we show that such behaviour may be very common in LLAGN. A similar anticorrelation is found in X-ray binary systems in the 'hard state', at low accretion rates similar to those of the LLAGN discussed here. Our observations thus imply that LLAGN are the active galaxy equivalent of hard state X-ray binaries.

A7: Reverberation Mapping of Accretion Disk Winds in Active Galactic Nuclei

Sam Mangham
University of Southampton

Reverberation mapping is commonly used for determining black holes masses in AGN from the delayed response of the Broad Line Region (BLR) to fluctuations in the intensity of the AGN continuum source. However, it can also be an effective tool for investigating the structure and kinematics of the BLR itself. Much prior work has been performed to simulate the transfer functions associated with a range of basic geometries (e.g. Keplerian disks, Hubble-like outflows, etc). One promising model for the BLR is that the emission lines are formed in an equatorial accretion disk wind. Here, we predict the reverberation signatures expected from such a model, by modifying the radiative transfer and ionisation code Python that has previously been used to model broad absorption line quasars. This allows to account self-consistently for ionization and radiative transfer effects in the predicted BLR response, which are normally ignored in such calculations. We discuss the agreement between our results and prior work and consider the possibility of detecting the signature of rotating equatorial disk winds in observations obtained by velocity-resolved reverberation mapping campaigns.

A8: REFLEX: A versatile MC code to study X-ray reflexion around AGN

Stéphane Paltani
University of Geneva

We present a new Monte Carlo code called REFLEX to simulate realistic reflection/transmission geometries of X-ray primary emission. REFLEX implements all the major physical processes of interaction of X-rays in cold matter. Its main difference compared to other similar models is its ability to define arbitrarily complex geometries by placing "clouds" of different shapes. In addition, the geometry of the emission and its spectrum can also be defined in a very flexible way. We validate REFLEX using well known models like pexrav/pexmon and MYTorus. As REFLEX is tracking individually all photons, it can be used to make interesting inferences. In particular, the propagation time of the photons allows the study of the time response of reflected spectra. On a more educative side, REFLEX can also generate spectral images of the reflecting medium, and each of the physical processes can be turned off individually. We show some applications of REFLEX for realistic AGN configurations like a disc torus reflector, and we explore the Compton shoulder in different cases.

A9: IFU Spectroscopy of 10 ETG nuclei: Properties of the circumnuclear gas emission

Tiago Vecchi Ricci
University of Sao Paulo

LINERs are galactic nuclei containing spectra with prominence of low-ionization lines. Several ionization sources are able to produce a LINER-like spectra (e.g. shocks, low-luminosity AGNs, pAGB stars). In this work, we will present an analysis performed on a sample of 10 massive ETGs with distances up to 30 Mpc. This sample was observed with the GMOS-IFU installed on the Gemini-South Telescope. The data cubes of the galaxies have a FOV of 3.5×5 arcsec2 and a spatial resolution of about 0.6 – 1.0 arcsec. After subtracting the stellar component of the galaxies by means of spectral synthesis, we studied the emission lines all over the FOV of the data cubes. In galaxies where an AGN was clearly detected, we found ionized gaseous discs and also a low-velocity extended emission perpendicular to the gas discs. We concluded that only ionizing photons emerging from the AGNs are not enough to photoionize the gaseous discs of the galaxies. On the other hand, it seems to be responsible for the photoionization of the low-velocity extended gas perpendicular to the discs. We propose a scheme where some collimating agent, somehow aligned to the gaseous discs, may be present in some LINER-like AGNs in the local universe.

A10: A Variable-Density Absorption Event in NGC 3227 mapped with Suzaku and Swift

Tobias Beuchert
University of Erlangen

We present new time-resolved spectroscopy of an eclipse event in NGC 3227 from a Swift and Suzaku campaign over several weeks in 2008. Observations of variable X-ray absorption over the past decade support the paradigm of clumpy circumnuclear gas. Eclipse events across multiple Seyferts and timescales allow us to explore the properties of the clumps over a wide range of radial distances from BLR scales to beyond the dust sublimation radius. Time-resolved density profiles so far are rare, but suggest a range of shapes, including centrally-peaked, comet-shaped, or doubly-peaked ones. In the case of the 2008 event, we resolve the density profile to be highly irregular and variable, in contrast to a previous symmetric and centrally-peaked event mapped with RXTE in the same object. The data indicate a filamentary, moderately ionized cloud that covers ∼90% of the line of sight to the central engine. The UV data show significant reddening that is still unable to explain the measured X-ray column. We suggest a dust-free cloud. Our results for the first time show a variety of profile shapes within the same source and thus provide an excellent opportunity to further test models describing the formation and dynamics of individual clouds or filaments as well as their distances from the supermassive black hole (SMBH).

Wednesday 16 September: Evolution

3.5 Wednesday 16 September - Oral Presentations

Unification and/or evolution?

Hagai Netzer
Tel Aviv University

Extending the unification scheme to high redshift may require a paradigm shift since conditions in the early universe are significantly different from those observed locally. In particular, the higher gas densities, and the different morphologies of the host galaxies, are likely to affect the geometry and dust content in the vicinity of the black hole. Major merger are likely to destroy the central torus-like structure on a short time scale and gas supply to the black hole, and star formation close to it, may take completely different forms. I will review these issues and confront some of the predictions with new observations and analysis of very luminous AGNs at z>2.

Cosmological Evolution of X-ray Selected AGNs and Synthesis of the X-ray Background

Yoshihiro Ueda
Kyoto University

We review the current understanding of the cosmological evolution of X-ray selected AGN up to $z \sim 5$, by mainly focusing on Ueda et al. (2014, ApJ 786, 104). Utilizing one of the largest X-ray AGN samples combined from various surveys with different flux limits, area, and energy band, we determine the space number density and obsuration properties of AGNs as a function of X-ray luminosity and redshift. They are used to construct a standard population synthesis model of the X-ray background, which includes the contribution of Compton thick AGNs. Implications from the key results are discussed.

Molecular line emission in NGC 1068 imaged with ALMA

Santiago Garcia-Burillo
OAN

We investigate the fueling and the feedback of star formation and nuclear activity in NGC1068, a nearby Seyfert 2 barred galaxy, by analyzing the distribution and kinematics of the molecular gas in the disk. We have used ALMA to map the emission of a set of dense molecular gas tracers and their underlying continuum emission in the central r=2 kpc of NGC1068 with spatial resolutions 0.3"-0.5" (20-35 pc). Molecular line and dust continuum emissions are detected from a r=200 pc off-centered circumnuclear disk (CND), from the 2.6 kpc-diameter bar region, and from the r=1.3 kpc starburst (SB) ring. We used the dust continuum fluxes measured by ALMA together with NIR/MIR data to constrain the properties of the putative torus using CLUMPY models and found a torus radius of 20(6,-10)pc. The gas kinematics from r=50 pc out to r=400 pc reveal a massive outflow in all molecular tracers. The tight correlation between the ionized gas outflow, the radio jet and the occurrence of outward motions in the disk suggests that the outflow is AGN-driven. The outflow rate estimated in the CND, dM/dt=63(21,-37)$M_{\odot}$/yr, is an order of magnitude higher than the star formation rate at these radii, confirming that the outflow is AGN-driven. The power of the AGN is able to account for the estimated momentum and kinetic luminosity of the outflow. The CND mass load rate of the CND outflow implies a very short gas depletion time scale of 1 Myr.

Peering through the nuclear dust of ULIRGs and quasars in the local universe with GTC/ CanariCam

Almudena Alonso-Herrero
Instituto de Física de Cantabria

The evolutionary connection between quasars and ultraluminous infrared galaxies (ULIRGs) was proposed almost thirty years ago. In this scenario ULIRG activity is triggered by interactions between gas galaxies. Numerical simulations predict that both intense star formation and a dust enshrouded quasar co-exit in the dusty nuclear regions of most local ULIRG. Plenty of observations of local ULIRG now support this scenario. While a lot of effort has been devoted to understand properties such the relation between the ULIRG luminosity and their morphology, merger state, star formation rate and AGN dominance, little is known about the detailed dust properties of their nuclear regions. We obtained nearly diffraction-limited (∼0.3arcsec) mid-infrared imaging and 7.5-13micron spectroscopy of a sample of local (U)LIRGs and quasars using the CanariCam instrument on the 10.4m Gran Telescopio CANARIAS. In this talk I will present recent results of the modelling of the nuclear infrared emission of these ULIRGs and quasars using the clumpy torus models of Nenkova et al. (2008). In particular I will discuss whether clumpy torus models provide an adequate description of the nuclear dust emission of both classes of galaxies.

Probing AGN Unification with galaxy neighbours: pitfalls and prospects

Beatriz Villaroel
Uppsala University

Statistical tests of AGN unification harbour many caveats. One way of constraining the validity of the AGN unification is through studies of close neighbours to Type-1 and Type-2 AGN. Examining thousands of AGN-galaxy pairs from the Sloan Digital Sky Survey Data Release 7 and the Galaxy Zoo project, we found that Type-2 AGN appear to reside in more star-forming environments than Type-1 AGN.

Observational constraints on the obscuration distribution of AGN to redshift z∼5

Antonios Georgakakis
MPE

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will discuss recent observational constraints on the space density of X-ray selected AGN as a function of redshift, accretion luminosity and obscuration, the latter parametrised by the hydrogen column density along the line-of-sight. I will emphasise the need for careful analysis to propagate various sources of uncertainty in the luminosity function calculation, e.g. photometric redshift uncertainties, optical unidentified sources, errors in the derivation of column densities or accretion luminosities associated with the Poisson nature of X-ray spectra. A Bayesian approach is developed to account for the uncertainties above. This is applied to both the Chandra and XMM survey data to determine the X-ray luminosity function to z=5. I will present results on the luminosity and redshift dependence of the obscured AGN fraction, including constraints on the most deeply shrouded, Compton think, population. I will then discuss these results in the context of AGN/galaxy co-evolution models.

Support for an Evolutionary Model of AGN Nuclei

Deborah Dultzin
UNAM

I will present our recent results (2013-2015) on the role of the environment in the nuclear activity of interacting Galaxies, all of which support an evolutionary sequence in the nuclear activity. We studied close galactic pairs of similar mass in the local Universe. We analyzed 385 spectra of S S, E E, and E S pairs, and try to disentangle the role of morphology on induced activity . We compare with our own sample of bona fide isolated galaxies containing a statistically significant number of all morphological types . Our main results are in conflict with the simplest version of the so called Unified Model (UM), and suggest that high accretion rates are essential to form the Broad Line Region in active galaxies. We also investigated the structure of the dusty torus surrounding Syfert 1 and 2 nuclei, both in pairs and isolated. The results also lead to a disagreement with the UM. Finally, we present our results on the Nuclear Activity in the context of the evolution of Compact Groups of galaxies over the past 3 Gyrs. Our analysis is based on the largest multiwavelength compact group sample to-date, and the results are also in conflict with an orientation obscuration effect alone.

Coevolution of supermassive black holes and circumnuclear dense molecular gas disk in Seyfert galaxies

Takuma Izumi
University of Tokyo

The energy emitted by an active galactic nucleus (AGN) is commonly ascribed to mass accretion onto a supermassive black hole (SMBH). However, the physics of angular momentum transfer at r $<$ 100 pc from the SMBH is still unclear. Interestingly, recent high resolution IR observations suggest a possible connection between a circumnuclear (i.e., $<$ 100 pc scale) star formation rate and a mass accretion rate onto a SMBH (e.g., Esquej et al. 2014). But to study such a tentative AGN-starburst connection in detail, it is also necessary to investigate properties of circumnuclear molecular gas, because such gas is the site of massive star formation, and also be the fuel for AGNs.

Therefore, we compiled interferometric data of the 100 pc scale circumnuclear molecular gas disk (CND) in nearby Seyfert galaxies, and found a (tentative) correlation between (1) a ratio of the mass of the CND and the mass of the SMBH and (2) a mass accretion rate onto the SMBH. The mass of the CND is estimated by using HCN(1-0) emission line, which is a typical tracer of dense molecular gas (unlike J=1-0 CO). This correlation can be expected in a turbulent disk

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An Observational Perspective on the Drivers of Torus Evolution

Ric Davies
MPE

I will begin by discussing the origin of the gas that makes up the torus. Observations show that gas flows in - either from the galaxy host or its environment - and settles in a thick disk on scales of 50pc. Even on these scales the column density is high enough to cause orientation dependent obscuration. Episodic, short-lived starbursts occuring in this region have a major impact on further gas inflow. This suggests that the torus is a dynamically evolving structure, the properties of which are, at least partially, dependent on gas flow from large scales. Turning to small scales, spatially resolved spectroscopy shows both ionised and molecular outflows originating on scales less than tens of parsecs. Despite this obvious influence of the AGN, I argue that (in contrast to the dust sublimation radius) the properties of the geometrically thick gas structure associated with the torus do not depend on AGN luminosity. This can make sense if the torus is sustained by a balance between inflow from large scales and outflow on small scales.

Properties and evolution of massive thick gas tori

Bernd Vollmer
CDS Observatoire Astronomique de Strasbourg

Galactic gas-gas collisions involving a turbulent multiphase interstellar medium (ISM) share common ISM properties: dense extraplanar gas visible in CO, large linewidths ($\sim$50 km s^{-1}), strong mid-infrared H2 line emission, low star formation activity, and strong radio continuum emission. Gas-gas collisions can occur in the form of ram pressure stripping caused by the rapid motion of a spiral galaxy within the intracluster medium, galaxy head-on collisions, compression of the intragroup gas and/or galaxy ISM by an intruder galaxy which flies through the galaxy group at a high velocity, or external gas accretion on an existing gas torus in a galactic center. We suggest that the common theme of all these gas-gas interactions is adiabatic compression of the ISM leading to an increase of the turbulent velocity dispersion of the gas. The turbulent gas clouds are then overpressured and star formation is quenched. Within this scenario we developed a model for turbulent clumpy gas disks where the energy to drive turbulence is supplied by external infall or the gain of potential energy by radial gas accretion within the disk. The cloud size is determined by the size of a continuous (C-type) shock propagating in dense molecular clouds with a low ionization fraction at a given velocity dispersion. This model of a turbulent clumpy torus will be compared to a collisional model which implies stable clouds. In all models the torus properties are mainly set by the external gas accretion rate. AGN tori will be compared to the Circumnuclear Disk in the Galactic Center and possible evolutionary torus phases will be discussed.

The Keck OSIRIS Nearby AGN Survey: The Nuclear Gas and Stellar Structure in the Central 200 pc of Seyfert Galaxies

Erin Hicks
University of Alaska Anchorage

We present the first results from the KONA (Keck OSIRIS Nearby AGN) survey, which used the integral field unit OSIRIS plus adaptive optics to probe down to scales of 5-10 parsecs in a sample of 40 Seyfert galaxies. With these K-band data we measure the two-dimensional distribution and kinematics of the nuclear stars, molecular gas, and ionized gas within the central few hundred parsecs. In the majority of the galaxies the molecular gas, traced by 1-0 S(1) H2, is in circular rotation in a geometrically thick disk that is co-spatial with the stellar disk inferred from the stellar kinematics. A significant fraction of the Seyferts exhibit kinematic signatures of inflow and/or outflow in the molecular gas that is superimposed on this disk rotation. The ionized gas in most galaxies shows evidence of outflows, and, in many cases, is interacting with the interstellar medium traced by the molecular gas. The sample consists of both type 1 and type 2 Seyferts, allowing for a statistical comparison of the nuclear stellar and gas properties in the subsamples and the identification of significant contributors to possible orientation effects. Differences in the prevalence of the primary fueling mechanisms inferred from the gas kinematics in the type 1 and 2 subsamples, as well as evolution of the nuclear properties with AGN luminosity, are investigated. The nuclear regions of Seyfert 2s known to have a hidden broadline region are also compared with the Seyfert 1s and non-HBLR Seyfert 2s, including characterization of the stellar population via spectral fitting.

Connections between AGN activity, star formation, and obscuratio

Dave Alexander
Durham University

In this talk I will review understanding of the connection between AGN activity and star formation and assess what impact this connection may have on AGN obscuration. I will take a multi-wavelength approach but will predominantly focus on studies based on X-ray, infrared, and radio observations. I will explore whether increased obscuration is seen in AGN in the distant Universe, when compared to the local Universe, and ask whether any differences are due to increased star-formation activity.

Accretion modes, environments and fuelling of Radio-loud AGN

Judith Ineson
University of Southampton

There is increasing evidence of an important dichotomy between high and low excitation radio-loud AGN (HERGs and LERGs). In particular, HERGs have a higher accretion rate than LERGs, and this appears to be related to their accretion methods. HERGs also inhabit a narrower range of cluster environments than LERGs.

We report recent work showing that the radio properties of LERGs are related to their cluster environments, and that this relationship appears to be driven by a correlation between central density and jet power. HERGs, in contrast, show no sign of this relationship. This is consistent with models in which LERGs are powered by gas ingested from the intra-cluster medium, while HERGs are fuelled from local gas reservoirs.

Black-hole masses, outflows and hot dust at high redshift

Liam Coatman
University of Cambridge

Black-hole (BH) masses for active galactic nuclei at high redshifts are crucial to understand BH-growth and the physics of the connection between quasars and their host galaxies. Currently, for redshifts z¿2, BH-mass estimates rely on single-epoch CIV emission-line widths obtained from optical spectra. CIV, and other high-ionisation emission lines, exhibit a broad range of morphology, including significant blue-shifts of up to several thousand km/s. These blue-shifts signal the presence of strong outflows, most likely originating in a disk wind. We have obtained near-infrared spectra for a sample of 20 SDSS quasars at 2 blue-shifted CIV emission and present some evidence for a systematic dependence of the hot dust emission in these quasars on the CIV emission line properties.

The nuclear and integrated FIR emission of Seyfert galaxies

Judit García González
Instituto de Física de Cantabria

We present far-infrared (70-500micron) observations obtained with Herschel/PACS and SPIRE of 33 Seyfert galaxies from the Revised Shapley-Ames (RSA) catalogue. We selected these galaxies because they are nearby (median distance of 33Mpc) and have estimates of the nuclear and integrated star formation rates (SFR) from mid-infrared sub-arcsecond resolution and Spitzer/IRS spectroscopy, respectively. We measure the far-infrared nuclear (1kpc), 2kpc, and integrated spectral energy distributions (SEDs) from the Herschel images and estimate the unresolved nuclear emission at 70micron where Herschel provides the best angular resolution (median 0.9kpc). The goal is to select galaxies in our sample whose 70micron is mostly due to dust heated by the AGN. We will compare the 70micron emission together with existing nuclear 1-10micron SEDs and 8-13micron spectroscopy with clumpy torus model predictions. To estimate the AGN-produced 70micron emission we use a number of criteria. These include: (1) elevated nuclear 70/160 micron colours with respect to the typical colours of star forming galaxies, (2) 70micron excess emission with respect to the fit of the far-infrared SEDs with a grey body, (3) dust temperature higher than typical values of star forming galaxies, and (4) comparison of nuclear SFR obtained from 70 microns and mid-IR indicators.

3.6 Wednesday 16 September - Poster Presentations

E1: The Cold Dust Content of Broad and Narrow-Line, Optically Luminous, nearby QSO

Andreea Petric
Gemini Observatories

Observations of the dynamics of stars and gas in the nuclear regions of nearby galaxies suggest that the overwhelming majority of spheroidal galaxies in the local Universe contain massive BHs and that, with some important caveats, the masses of those central BH correlate with the velocity dispersions of the stars in the spheroid and the bulge luminosities. Much research has been dedicated to understanding the mechanisms responsible for such a fundamental perhaps causal relation. An accurate census of the basic properties of the cold interstellar medium (ISM) in AGN host is pertinent to those investigations because cold molecular gas is the basic fuel for star-formation and black hole growth. We present high sensitivity observations taken with the Herschel Space Observatory to measure the cold dust content in a sample of 85 nearby ($z \leq 0.5$) QSOs chosen from the optically luminous broad-line PG QSOs sample and in a complementary sample of 85 narrow-line QSOs chosen to match the redshift and optical luminosity distribution of the broad-line targets. The FIR data are combined with near-infrared and mid-infrared measurements from the Two Micron All Sky Survey and the Wide-Field Infrared Survey Explorer to determine their IR spectral energy distributions which we use to assess aggregate dust properties. We investigate the relation between star-formation rates (SFRs) estimated from the IR luminosities and SFRs determined from measurements of the 11.3 micron PAH. The differences between the cold dust properties of narrow and broad line AGN will be discussed in the context of models that envision that quasar activity is triggered by gas-rich galaxy mergers.

E2: A Systematic Search for Changing-ÂLook Quasars in SDSS

Chelsea MacLeod
University of Edinburgh

AGN are known to be variable phenomena. However, it is only relatively recently that multiple spectra of the same AGN at highÂ redshift have become available, mainly in part due to large spectroscopic surveys such as the SDSS. I present results from a search for significant Broad Emission Line (BEL) changes in quasars selected based on their light curves in SDSS and PanÂSTARRS. Such changing-Âlook quasars can provide direct observational evidence for the physical processes happening within the AGN.

E3: An extended nuclear torus revealed in NGC 1068 thanks to polarimetric imaging at high angular resolution

Damien Gratadour
Observatoire de Paris Meudon

In this paper we show strong evidence for an extended nuclear torus at the center of NGC 1068 thanks to new adaptive optics assisted polarimetric observations in the near-infrared with SPHERE on the VLT. The orientation of the polarization vectors clearly evidences the presence of a structured hourglass-shaped bicone and a compact elongated nuclear structure perpendicular to the bicone axis. The linearly polarized emission in the bicone is dominated by a centro-symmetric pattern, but the central compact region shows a clear deviation from the latter with linear polarization aligned along a direction perpendicular to the bicone axis. We believe this extended patch of linear polarization to be the first direct evidence for an extended torus at the core of the archetypal Seyfert 2 galaxy.

E4: Gas kinematics in the inner kiloparsec of NGC 1386: a new clue to the torus-galaxy connection?

Davide Lena
Rochester Institute of Technology

We used the GMOS integral field unit on the Gemini South telescope to investigate the kinematics of the circum-nuclear ionized gas in the Seyfert 2 galaxy NGC 1386. We found that the dominant kinematic components can be explained as a combination of rotation in the large-scale galactic disk and a compact bipolar outflow along the axis of the AGN 'radiation cone'. However, there is also compelling evidence for an additional kinematic component which is consistent with outflow and/or rotation in a plane that is approximately perpendicular to the axis of the AGN radiation cone. We speculate that this is a wind which is both outfowing in the equatorial plane of the torus, and rotating about the axis of the radiation cones. From the emission line surface brightness distribution, we infer the torus inclination and opening angle.

E5: Hyper massive black holes in evolved galaxies

Fernando J. Romero-Cruz
Universidad de Guanajuato

From the SDSS DR7 we took a sample of 16733 galaxies which do not show all of the emission lines required to classify their activity according to the classical BPT diagram (Baldwin et al. 1981 PASP). Since they do not show these emission lines they are thought to be evolved enough so to host Hyper Massive Black holes. We compared their statistical properties with other galaxies from the SDSS DR7 which do show emission lines and confirmed that their M-sigma relationship correspond to HMBHs (Gutelkin et al. 2009 ApJ) and also that their SFH confirms evolution. We also analyzed them with a new Diagnostic Diagram in the IR (Coziol et al. 2015 AJ) and found that their position in the IR color space (W3W4 vs W2W3) correspond to AGN activity with current low SF, another confirmation of an evolved galaxy. The position of our final sample in the IR diagram is in the same region in which Holm 15A lies, this galaxy is considered to host the most massive BHs in the nearby universe (Lopez-Cruz et al. 2014 ApJL). The morphology of these galaxies (all of them are classified as elliptical) confirms that they are very evolved.
We claim that the hyper massive BH lie in galaxies very evolved and with very low SF and without clear AGN activity in the BPT diagram.

E6: Monitoring the temperature and reverberation delay of the circumnuclear hot dust in NGC 4151

Jörg-Uwe Pott
MPIA

We would like to present our work on optical-nir-broad band dust reverberation of a sample of nearby AGN, with exciting first results on NGC4151, as published in Schnuelle et al. A&A 2013 and recently in Schnuelle et al., A&A 2015, where we discuss that precise ($\leq$5% level) photometric monitoring of the AGN dust can be used to trace morphological changes in a given target even without resolving the detailed geometry, i.e. without using interferometry and kilometric baselines.
Eventually the combination of NIR-reverberation, interferometry and spectroscopy gives a unique tool to study dynamics of the circumnuclear dust confining the BLR, and our work focusses on working out timescales for torus dust formation, evolution and morphology changes.

E7: Low-z LoBAL QSOs: orientation or evolution?

Mariana Lazarova
University of Nebraska - Kearney

Low-ionization Broad Absorption Line QSOs (LoBALs) are redder type-1 QSOs characterized by broad, blue-shifted absorptions of Mg II, indicating gas outflows at velocities up to 0.2c. There is still much debate regarding the nature of these objects. In the orientation paradigm, LoBALs are present in all QSOs, but can only be observed along limited lines of sight that skim the obscuring torus. Conversely, in the evolution paradigm LoBALS have been interpreted as being a short phase in the early stages of the QSO lifecycle, when QSO-driven winds are expelling gas and dust from the central regions. To explore the suggestion by previous work that LoBALS are more likely to be observed in mergers and recently fueled QSOs, we conducted a morphological analysis of a volume-limited sample of 22 SDSS-selected LoBALs at $0.5 < z < 0.6$ using HST/WFC3. We find signs of recent or ongoing tidal interaction in 2/3 of the host galaxies, and detailed surface brightness analysis with GALFIT indicates that the vast majority have early-type morphologies. Our results confirm the high rate of mergers in LoBAL hosts and they further show that LoBALs can be observed at any stage of the merger when QSO activity is expected, according to numerical simulations. While the morphologies of these objects may support the evolution paradigm, their SEDs do not suggest they are a population of QSOs statistically different from optically-selected type-1 QSOs. We discuss the two possible explanations for LoBALs implied by our results.

E8: A New Black Hole Mass Estimate for Obscured Active Galactic Nuclei

Takeo Minezaki
University of Tokyo

We propose a new method for estimating the mass of a supermassive black hole, applicable to obscured active galactic nuclei (AGNs). This method estimates the black hole mass using the width of the narrow core of the neutral FeKα emission line in X-rays and the distance of its emitting region from the black hole based on the isotropic luminosity indicator via the luminosity scaling relation. First we examine the location of the FeKα line emitting region for type 1 and type 2 AGNs assuming the virial relation. We find that the FWHM of the neutral FeKα line core falls between the FWHM of the broad Balmer emission lines and its corresponding value at the dust reverberation radius for almost all targets, indicating that the major fraction of the neutral FeKα line core originates between the outer BLR and the inner dust torus. Next, we obtain the radius-luminosity relation for the neutral FeKα line core from these data and estimate the black hole mass MBH(FeKα) using this method. Then we compared MBH(FeKα) with other black hole mass estimates, such as the broad emission-line reverberation mass for type 1 AGNs, the mass based on the H2O maser, and the single-epoch mass estimate based on the polarized broad Balmer lines for type 2 AGNs. We find the correlations and consistencies between MBH(FeKα) and other estimates, which suggest that MBH(FeKα) is a potential indicator of the black hole mass for obscured AGNs. The ASTRO-H satellite will advance these studies significantly in the near future.

E9: A low-frequency radio continuum study of the FRI radio galaxy 3C31 with LOFAR

Volker Heesen
University of Southampton

We present a deep low-frequency study of 3C31, a well-studied FRI radio galaxy in the local Universe, using the Dutch Low-Frequency Array (LOFAR). Our radio continuum observations between 30 and 180 MHz allow us to study the population of cosmic-ray electrons (CRe) down to a Lorentz factor of 100. We find that in the inner jet region, within 100 kpc from the core, the radio continuum spectrum can be described by a power-law with a radio spectral index between -0.53 and -0.56, in fair agreement what is expected for first-oder Fermi acceleration by strong non-relativistic shocks. We trace the radio tails out to the furthest extent ever discovered, where 3C31 spans now roughly a degree in declination on the sky, corresponding to 1 Mpc spatial extent. The radio spectral index steepens considerably in the radio tails, indicative of spectral ageing of the CRe. We use an advective cosmic-ray transport model to measure the advection speed and magnetic field scale heights in the radio tails.

Thursday 17 September: Future Instrumentation

3.7 Thursday 17 September - Oral Presentations

The Inner Region of the Torus

Martin Ward
Durham University

It has long been recognised that the innermost region of the torus is the closest that dust grains can exist before being subject to evaporation. It has also been suggested that this distance from the central source is coincident with the outermost extent of the BLR. However, the evidence for this claim is not conclusive. My talk will focus on another emission line region that may be associated with the inner wall of the torus. That is the so-called "coronal line region", in which very highly ionised line species are emitted, typically requiring photon energies of greater than 100eV. Our current work involves a detailed case study of the Seyfert 1, Mkn110. We use a well defined observed SED, combined with a new energy conserving accretion disc model, as input for photionisation codes. We can rule out a range of SEDs (in the unobservable, extreme ultraviolet), and obtain predicted emission line luminosities and ratios consistent with those observed. We also explore consequences for the strength of the mid-IR silicate emission features. This is leading towards a self consistent picture of the processes within, and observables from, the inner region of the tous.

Comments on Dust Reverberation

Brad Peterson
Ohio State University

Dust reverberation is an important technique for studying the inner structure of AGNs and probing the properties of astrophysical dust, and even has some potential as a cosmological probe. We will discuss two recent results that pose a serious limitation to understanding dust reverberation at the present time. First, recent high-cadence monitoring of the UV and optical continuum in two AGNs, NGC 2617 and NGC 5548, have yielded unambiguous lags between variations of the UV continuum and corresponding variations of the continuum at longer wavelengths. In the absence of UV data, this leads to a systematic underestimate of the innermost radius where dust is found. This similarly leads to an underestimate of the size of the broad emission-line region, although it does not affect the AGN black hole mass scale, which calibrates out this effect. Second, broad-band monitoring of continuum variations in the optical through near-IR show that the innermost dust is not necessarily at the 'instantaneous sublimation radius.' The innermost dust can be considerably cooler than expected at the sublimation radius and thus can heat up without sublimating when the central continuum source becomes more luminous (see the poster by Pott).

Quasar Unification Via Disk Winds: From Phenomenology to Physics

Christian Knigge
University of Southampton

I will give an overview of a collaborative project aimed at testing the viability of QSO unification via accretion disk winds. In this scenario, most of the characteristic spectral features of QSOs are formed in these outflows. More specifically, broad absorption lines (BALs) are produced for sight lines within the outflow, while broad emission lines (BELs) are observed for other viewing angles. In order to test these ideas, we use a state-of-the-art Monte Carlo radiative transfer and photoionization code to predict emergent spectra for a wide range of viewing angles and quasar properties (black hole mass, accretion rate, X-ray luminosity, etc). It turns out to be relatively straightforward to produce BALs, but harder to obtain sufficiently strong BELs. We also find that it is easy to overionize the wind with realistic X-ray luminosities. In addition, we are using our code to test and improve hydrodynamic disk wind models for quasars. So far, we have been able to demonstrate that the treatment of ionization in existing hydrodynamic models of line-driven disk winds is too simplistic to yield realistic results: the modelled outflows would be strongly overionized and hence would not feel the line-driving forces that are asssumed to produce them. We have therefore embarked on an effort to model line-driven disk winds self-consistently by linking a hydrodynamics code with our ionization and radiative transfer code. Finally, we can also predict the reverberation signatures produced by disk winds, which can be directly compared to the results of the latest reverberation mapping campaigns.

Key Radio Unification Steps Before 1980 and Some Related Recent Radio Observations

Anthony Readhead
Caltech

Early radio work on unification culminated in the first VLBI images using closure phases as well as visibility amplitudes (1976-1979), which (i) convinced even the skeptics of the reality of superluminal motion; (ii) showed that the nuclear structures in both quasars and radio galaxies are one-sided jets, with the jets in radio galaxies aligned with the outer lobes and quasar jets usually strongly curved; (iii) showed that in radio galaxies the nuclear and outer jets (where present) point in the same direction; and (iv) explained the existence of the two populations of steep spectrum extended and flat spectrum compact radio sources by ascribing all these observational effects to orientation relative to the jet axis – i.e. to projection and relativistic beaming effects. Curiously this early unification work in the radio has been overlooked in most unification discussions even though it preceded the observations of broad lines in polarized emission from galaxies, which provided strong evidence for the torus. The early radio unification work will be briefly reviewed and some interesting developments in radio unification of the last few years will be presented and discussed.

AGN studies with JWST/MIRI

Karina Caputi
Kapteyn Astronomical Institute

The forthcoming James Webb Space Telescope (JWST) will revolutionize galaxy evolution studies from the epoch of reionisation to the present day. In particular, a new era will be open for mid-IR astronomy, as the JWST Mid-Infrared Instrument (MIRI) will improve by an order of magnitude the sensitivity and angular resolution that can currently be achieved at these wavelengths (5-28 microns). In this talk, I will focus on the new breadth of possibilities that JWST/MIRI will offer for AGN identification and characterisation up to high redshifts, and the implications for our understanding of the role of AGN within galaxy evolution. I will also discuss the complementarity of other JWST instruments in these AGN studies.

AGN science opportunities with the future PFI interferometer

Stefan Kraus
University of Exeter

As part of the "Planet Formation Imager" (PFI) project, we currently develop the roadmap for a future infrared high-angular imaging facility that will be optimised to study the planet formation processes in protoplanetary discs on the spatial scale of the Hill-sphere of the forming planets. Achieving this goal requires an infrared interferometric facility with kilometric baselines that would provide a 100-times higher angular resolution than what will be accessible with ALMA or the ELTs. Based on the specifications, it is clear that PFI could also revolutionise extragalactic astronomy. In this talk, I will give a general overview about the project, outline the technical implementations that we consider, and discuss possible applications in the AGN field, where PFI could imaging the dust distribution in AGN tori, determine dynamical black hole masses (through measurement of the rotation profile of the circumnuclear accretion disc), or measure direct geometric distances for a signficiant number of extragalactic objects.

Development of Instruments onboard ASTRO-H for Future X-ray Studies of Tori

Hirofumi Noda
RIKEN

The next astronomical X-ray satellite ASTRO-H will be launched by Japan Aerospace eXploration Agency (JAXA) in this Japanese fiscal year. It allows us to combine a simultaneous coverage of the 0.4-600 keV band, and a high energy-resolution spectroscopy in the 0.3-12 keV band with an FWHM energy resolution of < 7 eV at 6 keV. The wide-band capability is provided by several instruments; X-ray CCD cameras cover the 0.4-12 keV band at a focal plane of soft X-ray telescopes, a hard X-ray imager covers the 5-80 keV range with multilayer coating hard X-ray mirrors, and a non-focusing soft gamma-ray detector covers the 40-600 keV band. The high energy-resolution spectroscopy is realized by the X-ray micro-calorimeter array operated at 50 mK on a focal plane of the soft X-ray telescope. With the unprecedented performances, the ASTRO-H observations of active galactic nuclei are expected to give us important X-ray information about tori including their dynamics, size, ionization state and so on. In the present talk, we introduce the current status of developments of the instruments onboard ASTRO-H, especially focusing on the performance of the X-ray micro-calorimeter derived in the ongoing ground testing and calibration.

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