PUERTO VARAS

CHILE

10/12 - 14/12

2018

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J. DEXTER

K. WADA

J. KROLIK

T. ALMEYDA

J. GALLIMORE

M. STALEVSKI

E. STURM

B. VOLLMER

S. KAMENO

S. LAMASSA

T. STORCHI-BERGMAN

C. RAMOS ALMEIDA

S. GARCIA-BURILLO

A. DORODNITSYN

C. RICCI

M. BALOKOVIC

C.-H. CHAN

J. BRAATZ

S. MATEOS

R. MORGANTI

R. DAVIES

TORUS 2018

THE MANY FACES OF AGN OBSCURATION

SOC: A. ALONSO HERRERO • P. ARÉVALO • F. BAUER • F. COMBES • S. HÖNIG • V. IMPELLIZZERI
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TORUS 2018: The many faces of the AGN obscuration

Puerto Varas, Chile 10-14 December 2018

For the past 30 years, a toroidal structure in the equatorial plane around active galactic nuclei (AGN), the so-called dusty and molecular torus, has been considered a cornerstone of unified schemes of quasars and Seyfert galaxies. However, this picture has recently been challenged through high spatial resolution infrared observations by the discovery of polar elongated dust structures, rather than doughnut shaped distributions. Similarly, recent spatially unresolved X-ray observations have provided critical new insights into the toroidal obscurer and scatterer, potentially requiring a reinterpretation of long-established concepts. The first ALMA observations, for their part, have led to contradicting interpretations: either the submm emission is indeed dominated by a rotating torus structure, or it is dominated by an outflow, which would be more compatible with the elongated dust shapes seen in the infrared. Together with a dramatic increase in computational power, these observations have triggered a renaissance in modelling of the nuclear material, with models for the first time trying to not only explain the SEDs but also the spatial distribution of the dusty and molecular material. Further observational results are expected to revolutionise this picture in the coming years through the increased spatial resolution and sensitivity of ALMA and JWST, as well as the new generation of high-resolution X-ray spectrometers such as XARM.

Continuing the long tradition of international TORUS workshops, we are congregated here in Puerto Varas, Chile, to investigate the many faces of AGN obscuration. Considering the new theoretical and observational work carried out across the electromagnetic spectrum, the scientific goal of the workshop is to critically assess and challenge our current "common knowledge" and "widely accepted" torus picture. What do we really know for sure? What do we only think we know? And what is it that we do not know?

CHAIRS:

Franz Bauer
Violette Impellizzeri
Konrad Tristram

LOC:

María José Sepúlveda
Paula Sánchez-Sáez
Polina Ruvinskaya
Federica Ricci
Julián Mejía-Restrepo
Darshan Kakkad
Paulina Jirón
Claudio Ricci

SOC:

Almudena Alonso Herrero
Patricia Arévalo
Franz Bauer
Francoise Combes
Sebastian Hönig
Violette Impellizzeri
Makoto Kishimoto
Julian Krolik
Nancy Levenson
Paulina Lira
Chris Packham
Konrad Tristram
Thaisa Storchi Bergmann

Schedule overview

For the latest version, please consult on the conference website at http://www.torus2018.org/programme.html

Monday, December 10th
S&C: Structure and composition

Time	Duration		Speaker	Type	Title
09:00	5 min		Chairs	Opening	
09:05	30 min	A. Laor	J. Krolik	Intro	The many faces of the torus
09:35	30 min		C. Ricci	Review	Review Structure & Composition
10:05	20 min		S. Hönig	Talk	Hot, cool, dark and bright: The various shades of dust around AGN
10:25	25 min			Posters	Structure and composition (Agís González, Dall'Agnol de Oliveira, Kawamuro, Leftley, Lopez-Rodriguez, Rouan, Wildy)
10:50	30 min		COFFEE BREAK		
11:20	20 min	T. Storchi-Bergmann	D. Asmus	Talk	On the importance of polar dust in AGN
11:40	20 min		A. Prieto	Talk	The central parsec of the nearest AGN: challenges to the tourus
12:00	20 min		M. Kishimoto	Talk	The three dimensional distribution of AGN gas clouds at 1-100 pc scales
12:20	20 min		S. Sawada-Satoh	Talk	High resolution imaging of the molecular torus in NGC 1052 with VLBI
12:40	110 min		LUNCH BREAK		
14:30	25 min	D. Asmus	J. Dexter	Invited	The Resolved Size and Structure of Hot Dust in AGN
14:55	25 min		E. Sturm	Invited	Spatially resolved ordered rotation of a quasar broad line region - measuring sub-parsec structures around AGN with GRAVITY
15:20	20 min		M. R. Stock	Talk	Spectro-Interferometric Signatures of the Broad Line Regions in Active Galactic Nuclei
15:40	20 min		A. Laor	Talk	A very compact torus
16:00	30 min		COFFEE BREAK		
16:30	20 min	S. Sawada-Satoh	T. Waters	Talk	The characteristic sizes of individual broad and narrow line region clouds
16:50	20 min		F. Bauer	Talk	Ubiquitous Extended Fe K-alpha emission in AGN
17:10	20 min		J. Buchner	Talk	Geometry of the X-ray obscurer
17:30	20 min		G. Fabbiano	Talk	Hard Continuum and Fluorescent Iron Emission Beyond the Torus
17:50	50 min		C.R. Almeida & S.G. Burillo	Discussion	Structure and composition
18:40			End of day		

Tuesday, December 11th
R&V: Reprocessing & variability

Time	Duration		Speaker	Type	Title
09:00	25 min	M. Ward	B. Vollmer	Invited	Models of thick turbulent gas disks with magnetocentrifugal winds in AGN and their application to Circinus and NGC 1068
09:25	25 min		M. Stalevski	Invited	Towards a new paradigm of dust structure in AGN: Dissecting the mid-IR emission of Circinus galaxy
09:50	20 min		C. Andonie	Talk	Reconciling X-ray and IR observations of the Circinus Galaxy
10:10	20 min		M. Schartmann	Talk	The effect of circum-nuclear discs on the central gas and dust distribution
10:30	20 min		R. Nikutta	Talk	Hypercat - Hypercube of AGN tori
10:50	30 min		COFFEE BREAK		
11:20	30 min	S. Mateos	S. Lamassa	Review	Reprocessing & Variability
11:50	25 min		T. Almeyda	Invited	Reverberation mapping the nuclear dust emission in AGN from modeling to large surveys
12:15	20 min		P. Sanchez	Talk	Characterization of AGN variability in the optical and near infrared regimes
12:35	10 min			Posters	Reprocessing & Variability (Esparza Arredondo, Tanimoto, Bennert, De Cicco, Turner, Guise, Carraro)
12:45	105 min		LUNCH BREAK		
14:30	20 min	M. Stalevski	F. Pozo Nunez	Talk	A bowl-shaped dust torus geometry for the Seyfert 1 galaxies 3C120 and WPVS48
14:50	20 min		J. Esser	Talk	Using temporal variations of AGN emission line profiles to get indications on the structure of both the BLR and the dust torus
15:10	20 min		M. Ward	Talk	The Inner Torus/BLR "Disconnection"
15:30	20 min		M. Kokubo	Talk	Rapid Reformation of the Innermost Dust Distribution in the Changing-Look AGN Mrk 590
15:50	20 min		S. Mattila	Talk	A tidal disruption event in Arp 299 with much of its emission reradiated at infrared wavelengths
16:10	30 min		COFFEE BREAK		
16:40	20 min	T. Almeyda	D. Hutsemekers	Talk	Insight on quasar changing-look physics from optical polarimetry
17:00	20 min		B. Boulderstone	Talk	The Dust Sublimation Region in Nearby AGN
17:20	20 min		N. Osorio-Clavijo	Talk	X-ray multi-epoch variability of the Low-Luminosity AGN NGC 1052
17:40	20 min		A. Zaino	Talk	Investigating the nature and geometry of NGC 1068 through NuSTAR observations and future X-ray polarimetry
18:00	45 min		P. Arévalo & M. Kishimoto	Discussion	Reprocessing & variability
18:45			End of day		

Wednesday, December 12th
SUR: Torus in its surrounding

Time	Duration		Speaker	Type	Title
09:00	30 min	A. Prieto	T. Storchi-Bergman	Review	The torus in its surroundings
09:30	20 min		L. Burtscher	Talk	The star formation -- AGN link on 100 pc scales: Stellar populations in the nuclei of ultra hard X-ray selected AGNs
09:50	20 min		D. Lutz	Talk	BAT AGN prefer circumnuclear star formation
10:10	20 min		R. Riffel	Talk	Does star formation play a decisive rolein active galactic nuclei fueling?
10:30	20 min			Posters	Torus in its surrounding (Adhikari, Aydar, Azadi, Cassanta, Fuller, Kamali, Lopez-Rodriguez)
10:50	30 min		COFFEE BREAK		

Wednesday, December 12th
SUR: Torus in its surrounding

Time	Duration		Speaker	Type	Title
11:20	25 min	J. Gallimore	R. Morganti	Invited	The complex nuclear regions of young radio galaxies
11:45	20 min		R. Pfeifle	Talk	Obscuration Beyond the Torus: Assessing AGN Environments and Obscuration as a Function of Merger Stage
12:05	20 min		C. Carroll	Talk	An extreme population of heavily buried AGN: Identification and host galaxy characteristics
12:25	20 min		N. Levenson & L. Burtscher	Discussion	Torus in its surroundings
12:45	105 min		LUNCH BREAK		
14:30			Free Afternoon		

Thursday, December 13th
DYN: Dynamics

Time	Duration		Speaker	Type	Title
09:00	30 min	T. Izumi	J. Gallimore	Review	Torus Dynamics
09:30	25 min		J. Braatz	Invited	Water Megamasers
09:55	25 min		S. Kameno	Invited	A radio absorption study of AGN tori
10:20	20 min		A. Alonso-Herrero	Talk	The dusty molecular torus of Seyfert galaxies is full of surprises
10:40	10 min			Posters	Dynamics (Bianchin, Brum, Carpes, Ilha, Venanzi)
10:50	30 min		COFFEE BREAK		
11:20	25 min	A Constantin	S. Garcia-Burillo	Invited	The many 'faces' of the molecular torus of NGC1068
11:45	20 min		V. Impellizzeri	Talk	The counter rotating molecular torus in NGC1068
12:05	20 min		M. Imanishi	Talk	ALMA reveals a rotating dense molecular torus in NGC 1068
12:25	20 min		A. Audibert	Talk	NUclei of GAlaxies (NUGA) resolved by ALMA
12:45	105 min		LUNCH BREAK		
14:30	20 min	J. Braatz	T. Izumi	Talk	Circumnuclear Multi-phase Gas in the Circinus Galaxy Revealed with ALMA
14:50	20 min		K. Tristram	Talk	The compact molecular torus in the Circinus galaxy constrained by ALMA
15:10	25 min		C.-H. Chan	Invited	A new dynamical model of AGN tori
15:35	25 min		K. Wada	Invited	Dynamical pictures of tori and the multi-phase ISM
16:00	30 min		COFFEE BREAK		
16:30	25 min	M. Imanishi	A. Dorodnytsin	Invited	Hydrodynamical models of obscuring accretion disks and winds
16:55	20 min		D. Williamson	Talk	Radiative hydrodynamics of dust and gas in the "torus"
17:15	20 min		D. Angles-Alcazar	Talk	Simulating nuclear fueling in realistic environments
17:35	20 min		E. Treister	Talk	Molecular Gas in the Nuclear Regions of Nearby Dual AGN
17:55	40 min		A. A. Herrero & S. Hönig	Discussion	Dynamics
18:35			End of day		

Friday, December 14th
E&P: Evolution & Parameter Space

Time	Duration		Speaker	Type	Title
09:00	30 min	R. Morganti	C. Ramos Almeida	Review	Nuclear obscuration properties in AGN
09:30	25 min		M. Balokovic	Invited	Constraints on the Properties of the Torus from the NuSTAR Survey of Nearby Obscured AGN
09:55	20 min		P. Boorman	Talk	Resolving X-ray Obscuration Biases with Isotropic AGN Selection -- First Results from the NuLANDS Legacy Survey
10:15	20 min		L. Lanz	Talk	Reflection and Reprocessing in Swift/BAT AGN: Evidence of a Broad Range of Covering Fractions?
10:35	15 min			Posters	Evolution & Parameter Space (Ricci, Vecchi Ricci, Diaz, Diaz Santos, Yan, Lyu, Walter)
10:50	30 min		COFFEE BREAK		
11:20	20 min	C. Ricci	M. Elvis	Talk	The Effect of Extended Hard X-ray Emission on AGN Torus Parameters
11:40	25 min		S. Mateos	Invited	Covering fraction of the obscuring material around AGN
12:05	20 min		A. Constantin	Talk	Probing the Nature of the Obscuring Torus via Megamaser Activity
12:25	20 min		K. Ichikawa	Talk	BASS Survey: The Covering Factor of Dust and Gas in Swift/BAT AGN
12:45	105 min		LUNCH BREAK		
14:30	20 min	G. Fabbiano	N. Levenson	Talk	Opportunities with the James Webb Space Telescope
14:50	25 min		W. Jaffe / V. Gamez	Invited	What optical long-baseline interferometry can do for you
15:15	20 min		L. Burtscher	Talk	ELT/METIS and the torus
15:35	20 min		R. Morganti	Talk	Opportunities for torus observations with the SKA and other new radio facilities
15:55	40 min		S. La Massa & C. Packham	Discussion	Evolution & Parameter Space
16:35	30 min		COFFEE BREAK		
17:05	30 min	Impellizzeri	R. Davies	Review	A conference summary: is our changing look now only partially obscured?
17:35	5 min		Chairs	Closing Remarks	
17:40			End of day		

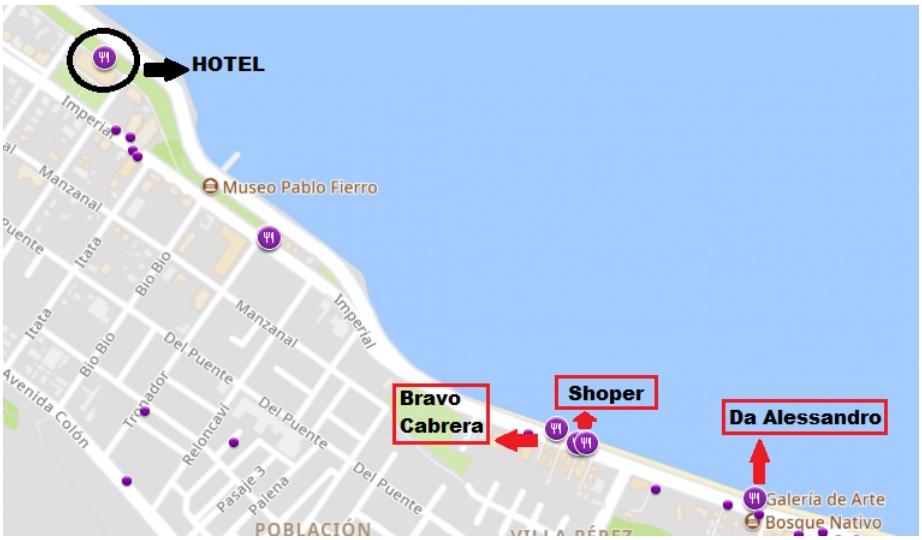
Welcome to TORUS-2018 at Puerto Varas!

Here you can find some useful information about nearby restaurants and pubs as well as information about the conference dinner.

Restaurants & Pubs

Restaurants nearby the hotel

- Mercado 605 (Mediterrean, wine bar, Chilean): Imperial 605
- Quintal (Chilean, Sudamericana, good for vegetarian): Imperial 650
- Puelche Restaurant (Brewery, Pub, Bar): Imperial 695, corner of Itata

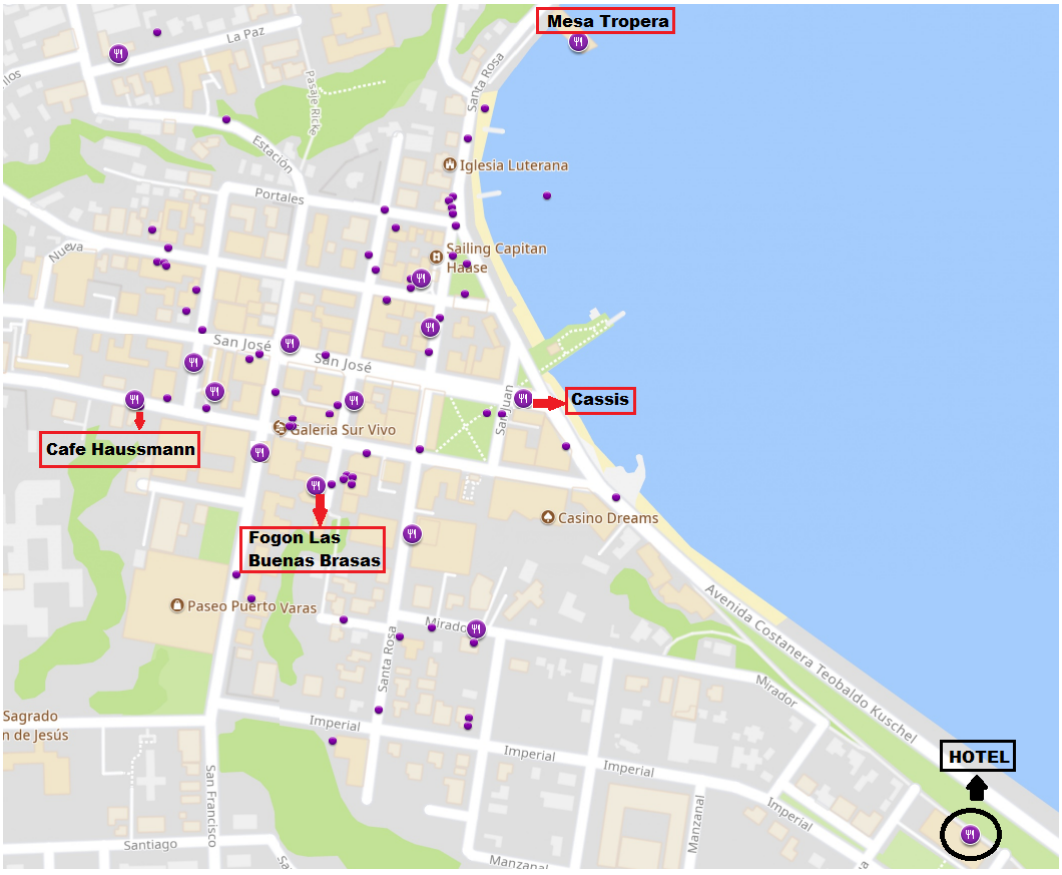


Toward Ensenada

- Da Alessandro (Italian, Pizza & Pasta): Avenue Vicente Perez Rosales 1290
- Bravo Cabrera (Pizza, Bar, Pub): Avenue Perez Rosales 1071
- Shoper (Brewery, Pub, Bar): Avenue Perez Rosales 1137

Toward Downtown

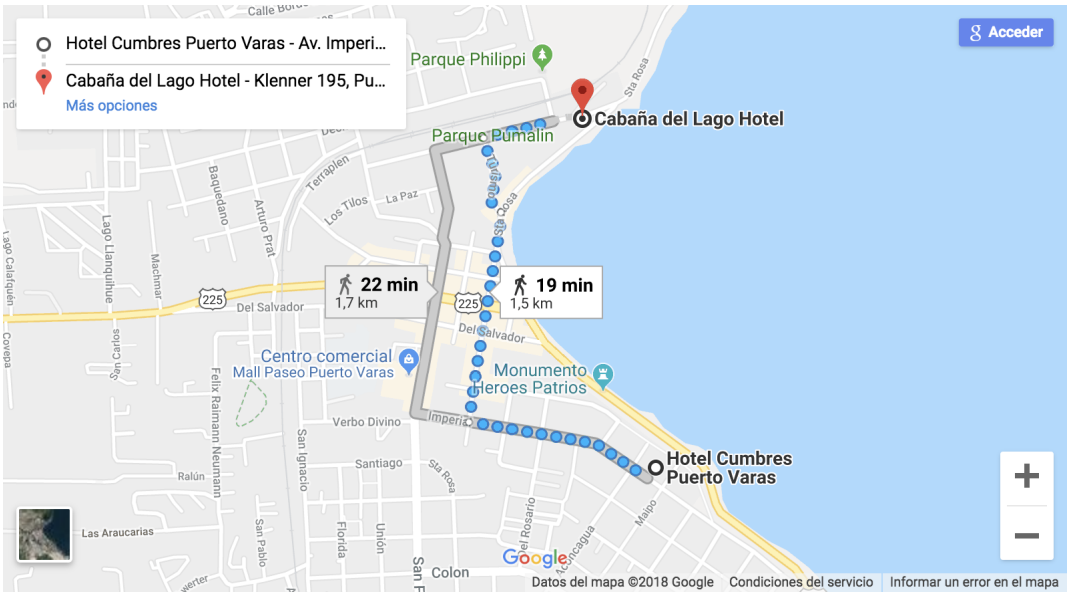
- Mesa Tropera (Italian, brewery, Bar): Santa Rosa 161, Yate Club (lakeshore)
- Cafe Haussmann (Bar, Cafe, Pub): San Francisco 644
- Fogon Las Buenas Brasas (Latin, seafood, soups): San Pedro 543
- Cassis Chocolates & Café (Cafe, South American, good for vegetarian): San Juan 431 corner of San Jose



Conference Dinner

The conference dinner will take place on Thursday, December 13th, at Hotel Cabaña del Lago, which is located in Klenner 195 in Puerto Varas. This is about 20 minutes walking distance from the conference venue at Hotel Cumbres along the lake shore to the North, on the other side of the centre of Puerto Varas (see map below).

The dinner will start with a reception at 19:30 in “Salón Petrohue” and we will then have the dinner in “Salón Mirador” with an amazing view to the lake and the volcano.



Contents

Introduction

The many faces of the torus obscuration

Monday
9:05

Julian Krolik, John Hopkins
jhk@jhu.edu

General introduction to the meeting

Structure and Composition

Monday
9:35

Nuclear obscuration in AGN: an X-ray perspective

Claudio Ricci, Universidad Diego Portales/Kavli Institute for Astronomy and Astrophysics
claudio.ricci.astro@gmail.com

Most of the accretion onto supermassive black holes (SMBHs) happens during a phase in which the AGN is obscured. This obscuring material could also provide the fuel that ultimately powers AGNs, so that a clear understanding of its origin and evolution is fundamental to shed light on the growth of SMBHs. However, to date it is still not clear what are the mechanisms regulating the column density and covering factor of the dusty gas that surrounds SMBHs. X-ray emission is an ubiquitous property of Active Galactic Nuclei and, being produced within a few gravitational radii from the black hole, it can provide fundamental information about the structure and geometry of the circumnuclear material. In my talk I will review our current understanding of obscuration in AGN from an X-ray perspective, focussing on its relation with the properties of the host galaxy and with those of the accreting SMBHs.

Monday
10:05

Hot, cool, dark and bright: The various shades of dust around AGN

Sebastian Hönig, University of Southampton
S.Hoenig@soton.ac.uk

Advancements in angular resolution over the last decade have allowed us to resolve the infrared-emitting dusty region around AGN. While a lot of thought has been put into interpreting the spatial and spectral distribution of the emission in terms of the dynamical state of the "torus" region, we are also looking into a unique environment where dust itself is processed in the hard radiation field of the AGN. In this talk, I will discuss the new constraints we can set on the dust size and chemical composition from high-angular resolution observations and how they affect our interpretation and modelling of the dust emission. Specifically, there is strong evidence that large grains play a much bigger role in shaping the infrared emission than one would expect from standard ISM dust. I will also discuss the effect of the AGN on PAH emission, provoking thoughts on its common use as a star-formation tracer.

On the importance of polar dust in AGN

Monday 11:20

Daniel Asmus, University of Southampton

d.asmus@soton.ac.uk

Recent observational results suggest that the mid-infrared emission of AGN is dominated by dust in the polar regions extending up to many parsec scales. This is difficult to explain with canonical torus models, either clumpy or smooth. Instead, it suggests the presence of dusty winds driven by radiation from the central accretion disk. Here, we will review the current evidence of polar dust in AGN and present new deep high-angular resolution mid-infrared observations of a local AGN sample testing the ubiquity of this phenomenon in AGN. Using the full sample of all AGN with resolved polar dust emission, we will compare our newly developed 3D radiative transfer models of a physically and observationally motivated AGN dust structure with current clumpy torus models to assess which ones can better represent the observational data including both SEDs and morphologies. The result provides strong constraints on the importance of polar dust in the mid-infrared regime and the radiative energy balance between winds and tori.

The central parsec of the nearest AGN: challenges to the torus

Monday 11:40

Almudena Prieto, IAC

aprieto@iac.es

The PARSEC project is a multiwavelength investigation of the central parsecs of the nearest galaxies across the entire electromagnetic spectrum. PARSEC results are providing us with a view of the nuclear region a bit different, somewhat simpler, than that envisaged by the canonical AGN Unification Schemes. I will discuss the challenges that parsec-scale observations in the IR when combined with comparable physical scales in radio, millimetre, optical, UV and X-ray of some of the nearest AGN are telling us about the nature of the nuclear emission, the transition from the most luminous to the feeble ones, and their accretion power. I will discuss how these observations challenge the requirement of a torus and question one of its fundamental attributes which is the collimation of the nuclear radiation.

Monday 12:00

High resolution imaging of the molecular torus in NGC 1052 with VLBI

Satoko Sawada-Satoh, JSF/NAOJ

swdsth@gmail.com

High angular resolution studies of molecular gas in the center of the extragalaxies (< 1 kpc) have been obtained with millimeter interferometers. The size of the torus, however, is smaller than 10pc, and a milliarcsecond (mas) resolution is required to study its internal structure in nearby AGNs. VLBI observations have revealed the parsec- or subparsec- scale morphology of nearby AGNs. Although thermal emission lines from molecular gas are not luminous enough to detect with the VLBI, VLBI maps can display thermal absorption lines of the gas in silhouette against a bright background synchrotron radiation source with a mas resolution. We present the first VLBI detection of HCN molecular absorption in the nearby AGN NGC 1052. The absorption features are localized on the receding jet side, where the free-free absorption occurred due to the torus.

Monday 12:20

First successful MATISSE observations of NGC 1068

Violeta Gamez Rosas, Leiden Observatory

gamez@strw.leidenuniv.nl

MATISSE, the second generation mid-infrared spectro-interferometer for the VLTI, offers exciting new opportunities to observe the innermost dusty regions of AGNs. By providing us with closure phases for the first time in the thermal infrared at high sensitivity, it will allow us to do true imaging on sub-parsec scales. This is critical to address the still open questions that emerged with MIDI and some that remain unanswered since the early history of AGNs. I will talk about the first successful MATISSE observations of the relatively close (14.4 Mpc) Type II Seyfert galaxy NGC 1068, their limitations and challenges, and their very interesting results.

The Resolved Size and Structure of Hot Dust in AGN

Monday 14:30

Jason Dexter, Max Planck Institute for Extraterrestrial Physics (MPE)
jdexter@mpe.mpg.de

Long baseline infrared interferometry can spatially resolve the obscuring dust around AGN. Past near-infrared observations found sizes consistent with the expected sublimation radius, while the mid-infrared warm dust was found to have extended, polar components - a challenge to the "torus" paradigm. The new VLTI instrument GRAVITY greatly improves the sensitivity and spatial coverage of near-infrared interferometry. From our collaboration's results on AGN to date, I will show cases of compact as well as elongated and asymmetric hot dust emission that may originate in the walls of an ionization cone or a polar outflow.

Spatially resolved ordered rotation of a quasar broad line region - measuring sub-parsec structures around AGN with GRAVITY on the VLTI

Monday 14:55

Eckhard Sturm, Max Planck Institute for Extraterrestrial Physics (MPE)
sturm@mpe.mpg.de

Atomic emission lines broadened by high velocity motion near accreting supermassive black holes are an observational hallmark of quasars. Connecting the torus region to the accretion disc they hold the potential to constrain black hole masses and the transport mechanism of material inward through the accretion disc or outward through a wind. However, little is known about the size of this broad line region (BLR), its gas distribution or kinematics. In some models the emission lines arise from a continuous outflow, while others employ orbiting gas clouds. Directly imaging the BLR to probe its structure and dynamics has not been possible because of its small angular size, < 0.1 milli-arcseconds. We will report the first direct measurement of a spatial velocity gradient across the BLR of a quasar (3C 273) with an angular size of ten micro-arcseconds ($\sim$0.03 parsec for a distance of 550 mega-parsecs). The velocity gradient is approximately perpendicular to the radio jet in inclination and position angle: a clear signature of ordered rotation. After a brief introduction of the GRAVITY instrument and its potential for AGN research (e.g. spatially resolved structure and kinematics of torus and BLR), we will illustrate these principles with the details of the measured size and BLR structure in 3C273, its black hole mass, and the implications for reverberation mapping techniques.

Monday
15:20

Spectro-Interferometric Signatures of the Broad Line Regions in Active Galactic Nuclei

Matthias Raphael Stock, Max Planck Institute for Extraterrestrial Physics

raps@mpe.mpg.de

The sensitivity of the VLTI/GRAVITY instrument opens up the possibility to directly resolve the broad emission line regions (BLRs) of the brightest active galactic nuclei (AGN) on a scale of tens of micro-arcseconds by measuring a wavelength-dependent phase shift at the emission lines relative to the continuum. Exploiting these new data scientifically requires a model of the BLR. We present a phenomenological model based on a collection of optically thin, orbiting clouds. For instance, the model parameters include the radial distribution of the clouds or the thickness of the BLR structure. Comparing the model predictions for spectral lines and differential phases with GRAVITY data of quasars constrains their orientation, structure, and dynamics, and provides an independent estimate of black hole mass. Additionally, model predictions for various AGN will improve the target selection for future observations. These observations and their interpretation based on our modeling hold promise to reveal the physical origin of the BLR and provide critical tests of the reverberation mapping method and resulting radius-luminosity relation, which currently form the basis of all AGN mass estimates in high redshift surveys.

Monday
15:40

A very compact torus

Ari Laor, Technion

laor@physics.technion.ac.il

A likely origin for the BLR is a dust inflated outer disk (Baskin & Laor 2018). This inflated torus structure is expected to subtend over a significant solid angle, with an effectively infinite optical depth. It thus inevitably forms an obscuring torus. I will show further polarization evidence that the scattering medium in type 1 AGN is on the BLR scale, which may imply that the BLR is the primary torus.

The characteristic sizes of individual broad and narrow line region clouds

Monday 16:30

Tim Waters, Theoretical Division, Los Alamos National Laboratory

waters@lanl.gov

An emerging paradigm for the nature of the broad and narrow line clouds is that of condensations embedded in the global outflow or inflow. Since clumpy outflows or accretion flows are naturally turbulent, the appropriate way to model the dynamics of individual clumps is by studying the evolution of thermal instability in triply periodic, driven turbulence simulations. I present the results of the first such simulations for BLR and NLR parameters. Moderately strong turbulence only allows the fastest growing modes of TI to condensate, and this simple result has rather remarkable implications: given the central engine's SED as well as the density and temperature of UV absorbers (determined via photoionization modeling), it is possible to predict from first principles the sizes of the individual clumps, their formation and disruption timescales, and the intercloud plasma temperatures. This in turn implies that we can calculate the covering fraction and characteristic variability timescales that should be seen in absorption studies, as well as the higher ionization lines that should appear in absorption due to the hot phase.

Ubiquitous Extended Fe K-alpha emission in AGN

Monday 16:50

Franz Bauer, Pontificia Universidad Católica de Chile - Instituto Milenio de Astrofísica

fbauer@astro.puc.cl

I will present results from archival Chanda data demonstrating that the bulk of observed Fe K-alpha emission in nearby AGN is spatially extended on scales well beyond of the fiducial torus ($>>$ 1-10 pc). The most likely scenario is that this line emission originates close to the AGN, but is scattered into our line-of-sight as it escapes from the host galaxy. A key implication of this is that spatially unresolved X-ray spectroscopy measures the angle-averaged Fe K-α emission, and not the line-of-sight emission. Moreover, when spatially resolved the morphology of the Fe K-alpha emission should provide insights on both the torus covering factor and clumpiness, as well as the content and structure of the scattering medium.

Monday
17:10

Geometry of the X-ray obscurer

Johannes Buchner, Pontificia Universidad Católica de Chile
johannes.buchner.acad@gmx.com

The geometry of the nuclear obscurer is currently unknown. It has to have a large covering that produces the diversity of unobscured and obscured AGN, while avoiding collapse. Additionally, variable obscuration events indicate clumpiness. To go beyond the donut, we explore several new geometries (unified clumpy models, warped disks and the radiative fountain model) for the X-ray obscurer. A new X-ray Monte Carlo code allows us to transform arbitrary geometries into X-ray spectra, which we make publicly available. When comparing to observations of local obscured AGN with NuSTAR, we find strong preferences for some geometries. Generically, observed spectra seem to be primarily created by a large-area smooth, cold reflecting surface near the corona. This disfavors clumpy / wind geometries by themselves. Warped disk or donuts fit better. These may still be combined with a thin, clumpy, polar wind.

Monday
17:30

Hard Continuum and Fluorescent Iron Emission Beyond the Torus

Giuseppina Fabbiano, Center for Astrophysics, Harvard & Smithsonian
gfabbiano@cfa.harvard.edu

It is a well-established tenet of AGN lore that the hard continuum and fluorescent Fe K emission originate from the interaction of the nuclear photons with the obscuring Compton Thick (CT) torus. Spectral modeling of the AGN torus is based on this assumption. Chandra observations are beginning to question this belief. We present the example of ESO 428-G014, a CT AGN that has been recently studied with deep Chandra ACIS-S observations. In this galaxy >30% of the hard continuum and Fe K emission is extended on kpc-scale, suggesting that the interaction of nuclear photons with the molecular clouds in the galaxies significantly adds to the circumnuclear scattering. Moreover, the hard continuum and the soft X-ray emission commonly associated with the ionization cone of this galaxy are extended in the cross-cone direction, echoing previous reports on the X-ray emission of the ionization cones of NGC 4151 and Mkn 573. These observations suggest a possibly porous cone, or not yet well-understood interactions of the radio jets with the dense ISM of the galaxy.

Reprocessing & variability

Models of thick turbulent gas disks with magnetocentrifugal winds in AGN and their application to Circinus and NGC 1068

Tuesday
9:00

Bernd Vollmer, Observatoire astronomique de Strasbourg

Bernd.Vollmer@astro.unistra.fr

We developed a model scenario for the inner 30 pc of an AGN where the structure of the gas is entirely determined by the gas inflow from larger scales. This external gas accretion adds mass and injects energy via gas compression into a gas dis and drives turbulence making the disk thick. We extended the description of a massive turbulent thick gas disk developed in a recent paper by adding a magnetocentrifugal wind. The toroidal magnetic field associated with the thick gas disk is responsible for driving the magnetocentrifugal wind at a distance of $\sim$ 1 pc from the central black hole. Once the wind is launched, it takes over the transport of angular momentum and the gas disk can become thin. It is shown that magnetocentrifugal winds starting from a thin and thick gas disk are viable in active galaxy centers. The outflow scenario can account for the elongated dust structures, outer edges of the thin maser disks, and molecular outflows observed in local AGN. We built 3D density cubes based on this analytical model, illuminated them with a central source, and made radiative transfer calculations. From the MIR images we calculated mid-infrared (MIR) visibility amplitudes and compared them to available interferometric observations. The models reproduce the observed terminal wind velocities, the scatter of the MIR - intrinsic X-ray correlation, and point source fractions. An application of the model to the Circinus galaxy and NGC 1068 shows that the infrared spectral energy distribution, available MIR interferometric observations, and optical polarization can be reproduced in a satisfactory way, provided that (i) a puff-up at the inner edge of the thin disk is present and (ii) a local screen with an optical depth of $\tau_V \sim 20$ in form of a local gas filament and/or a warp of the thick disk hide a significant fraction of both nuclei.

Tuesday
9:25

Towards a new paradigm of dust structure in AGN: Dissecting the mid-IR emission of Circinus galaxy

Marko Stalevski, Ghent University
marko.stalevski@gmail.com

Recent observations that resolved the mid-infrared (MIR) emission of active galactic nuclei (AGN) for the first time, surprisingly revealed that their thermal dust emission appears extended in the polar direction, at odds with the expectations from the canonical dusty torus. This polar dust, tentatively associated with dusty winds driven by radiation pressure, is found to have a major contribution to the MIR flux from parsec-scale to hundreds of parsecs. One such source with clear detections of the polar dust is a nearby, well-known archetypal AGN in Circinus galaxy. Being the second brightest AGN in the MIR and allowing high intrinsic spatial resolution, Circinus offers one of the best opportunities to study MIR emission in greater detail. The parsec-scale MIR emission of Circinus was resolved by the MID-infrared Interferometric instrument (MIDI) at the Very Large Telescope Interferometer (VLTI) into a disk-like component coinciding with the disk observed in maser emission and component extending in a polar direction, along the ionization cone seen in the optical. High-quality MIR images obtained with the upgraded VISIR instrument at the VLT show a bar-like structure extending up to at least 40 pc on both sides of the nucleus along the edges of the ionization cone. Motivated by observations across a wide wavelength range and on different spatial scales, we propose a phenomenological dust emission model for the AGN in the Circinus galaxy consisting of a compact dusty disc seen almost edge-on and a large-scale hollow dusty cone, illuminated by a tilted accretion disk. Undertaking detailed radiative transfer simulations, we demonstrate that such a model is able to explain well the MIR morphology of Circinus both on small and large scales. Furthermore, we demonstrate that the interferometric data rules out a presence of a geometrically thick clumpy dusty torus. Our results call for caution when attributing dust emission of unresolved sources entirely to the torus and warrant further investigation of the MIR emission in the polar regions of the AGN. We propose the here presented model of the Circinus as a prototype for the dust structure in a population of AGN with polar dust.

Tuesday
9:50

Reconciling X-ray and IR observations of the Circinus Galaxy

Carolina Andonie, Pontificia Universidad Católica de Chile
cpandonie@uc.cl

The Active Galactic Nuclei (AGN) Unification has been challenged in the last years, since in some AGN, a new emitting structures beyond the torus was found. In particular, for the Circinus Galaxy several recent investigations have found a dusty extended emission perpendicular to the torus plane that emits an important fraction of the total infrared flux. Stalevski et al. (2017) proposed a model for the Circinus Galaxy that explain the infrared data: a hollow cone, that explain the dusty extended emission, and a flared disk in the equatorial plane. In my presentation, I will discuss, for the first time, an X-ray model based on the morphology of the infrared model. The model was compared with NuSTAR, XMM-Newton and Chandra data of Circinus. The results of the research indicate that the infrared model alone cannot easily reproduce the X-ray data, since the covering factor of the flared disk is too low. We discuss how to reconcile these results with the infrared observations of this fascinating source.

The effect of circum-nuclear discs on the central gas and dust distribution

Tuesday 10:10

Marc Schartmann, University Observatory Munich / MPE
schartmann@mpe.mpg.de

Circum-nuclear discs are ubiquitously observed in nearby Seyfert galaxies on several 100pc scales. Our 3D hydrodynamical, adaptive mesh refinement simulations including self-gravity, star formation and stellar feedback show that they play an important part in the life cycles of galactic nuclei: initially quasi-stable gas discs undergo Toomre instability which finally leads to the formation of dense clumps that form stars and get partially dispersed by stellar feedback. In this talk, I will concentrate on the consequences these models have for the gas and dust distribution in the central few parsec region. Still embedded in the gas and newly formed stellar disc, the clumps are subject to dynamical friction. This leads to an inward drift and merging into the central density concentration (identified as the torus), leading to very dynamic, time- and space-dependent obscuration during this evolutionary phase. The latter seems to find correspondence in the recently found diversity of AGN tori in mid-IR interferometry. In the last part of my talk, I will concentrate on the (sub-)structure of AGN tori and how it relates to observable quantities, like spectral energy distributions as well as images and visibilities. Upcoming instruments like MATISSE, as well as ALMA in its most extended configuration will for the first time allow such detailed comparison. We aim at providing a suite of hydrodynamical simulations of the turbulent interstellar medium combined with radiative transfer calculations of state-of-the-art, multi-component, geometrical toy models. Together with the mentioned upcoming observations, this might allow us to learn something about the physical state of the gas in AGN tori and pinpoint possible drivers of turbulence.

Hypercat - Hypercube of AGN tori

Tuesday 10:30

Robert Nikutta, NOAO
nikutta@noao.edu

Unification and observations hold that a dusty torus obscures the central accretion engine along some lines of sight. SEDs of dust tori have been modeled for a long time, but resolved emission morphologies have not been studied in much detail, presumably because resolved observations are only possible recently (VLTI, ALMA) and in the near future (TMT, ELT, GMT). Some observations challenge a simple torus model, because in several objects most of the MIR emission appears to emanate from polar regions high above the equatorial plane, i.e. not where the dust supposedly resides. We introduce our open-source software and hypercube of AGN tori (Hypercat) made with CLUMPY (www.clumpy.org). The hypercube is a large set of images (6 model parameters + wavelength) generated by a physical model, which Hypercat can interpolate continuously. Another n-cube contains the 2-d projected dust maps. Users can provide their own model hypercubes if they so desire. The image and dust hypercubes will enable the community to study emission and dust morphologies in resolved observations. Hypercat can simulate such observations of nearby AGN, both with extremely large single-dish telescopes and with interferometers, including PSF modeling and convolution, detector pixelization, noise modeling and image deconvolution. We investigate the morphological properties of the 2-d light and dust distributions as functions of model parameters. We find that a simple clumpy torus can easily produce N-band emission patterns extended in polar directions, showing elongations compatible with those found in observations. We also constrain the range of parameters that produce such morphologies.

Tuesday
11:20

Insight into AGN Physics & Structure via Variability

Steph Lamassa, Yale University
slamassa@stsci.edu

AGN variability ranges from mild to extreme, and acts as a probe of AGN structure and accretion physics. In this talk, I will review how reverberation mapping is used to measure the radial extent of the broad line region through to the obscuring torus. I will highlight how AGN variability provides insight into changes within the AGN obscuring medium and how most recently discovered changing-look AGN are best described by variations in the ionizing continuum, implicating the accretion disk as the driver.

Tuesday
11:50

Reverberation mapping the nuclear dust emission in AGN from modeling to large surveys

Triana Almeyda, University of Southampton
t.r.almeyda@soton.ac.uk

The basis of dust reverberation mapping is that the size of the emitting region is directly related to the lag between the AGN optical continuum variations and the IR emission of the dust. Although this method is applicable over a large redshift range, the response is sensitive to many poorly constrained variables including the geometry and illumination of the dust distribution, which complicates the interpretation of measured reverberation lags. Thus, a dust reverberation mapping code, TORMAC, was developed to help extract the structural information embedded in the IR response by simulating the temporal response of the IR emission of a 3D ensemble of dust clouds given an input optical light curve. TORMAC accounts for anisotropic emission from the dust clouds, inter-cloud and AGN-cloud shadowing, polar clouds, and anisotropic illumination of the torus by the AGN continuum. We have computed a library of IR response functions to quantify the relationship between the lag and the effective size of the dust emitting region at selected wavelengths. Although the shapes of the response functions vary widely over our grid parameter range, the reverberation lag provides an estimate of the effective torus radius that is always within a factor of 2.5. This result and the observed tight correlation of dust reverberation time lags with AGN luminosity, $\tau \propto l^{0.54}$, shows that we can use AGN as a cosmological standard candle. This is the goal of the VISTA Extragalactic Infrared Legacy Survey (VEILS), the first wide and deep IR extragalactic time domain survey. VEILS is monitoring about 500 AGN in the optical and near-IR for at least 3 years with the first 2 almost completed. Here, I present preliminary light curves of AGN from our survey and discuss how we plan on mapping the dust time lags of AGN over a range of redshifts, $0 < z < 1.2$, allowing us to independently constrain cosmological parameters and establish AGN dust time lags as a standardizable candle.

Characterization of AGN variability in the optical and near infrared regimes

Tuesday 12:15

Paula Sanchez, ESO - Universidad de Chile
pasanchez@ug.uchile.cl

Several efforts have analyzed Active Galactic Nuclei (AGN) variability in the optical range, however, to relate the variability and physical properties of supermassive black holes (SMBHs), we need well sampled light curves, which are still rare. At the same time very little is known about variability in the near infrared regime (NIR), which at redshifts lower than 1.2 can give us information about the dust surrounding the accretion disk. In this talk I will present our statistical analysis of the connection between AGN variability and physical properties of the central SMBH, where we found that the amplitude of the variability depends solely on the rest frame emission wavelength and the Eddington ratio. Besides, I will present the results of our Dust Reverberation Mapping analysis, where we are using NIR and optical light curves of ∼100 type 1 QSO, with redshifts bellow 1.2, to study whether the emission received in the NIR is consistent with emission from a dusty torus, a wind or the accretion disk, and to determine the characteristic optical-NIR time lags, to study the different sizes of the AGN structures.

A bowl-shaped dust torus geometry for the Seyfert 1 galaxies 3C120 and WPVS48

Tuesday 14:30

Francisco Pozo Nunez, Astronomisches Institut, Ruhr–Universität Bochum, Universitätsstraße 150, 44801 Bochum, Germany
francisco.pozon@gmail.com

We present the results of a two years reverberation mapping monitoring campaign of the local active galactic nuclei (AGNs) 3C120 and WPVS48. We obtained high-quality sampling optical and near-mid-infrared data with small (15 to 80 cm) robotic telescopes at the observatory of the Ruhr-University Bochum, located in the Atacama desert in Chile, and with the Spitzer Space Telescope. The data allow us to simultaneously explore the geometry of both the Hα broad line region (BLR) and the dust torus. The analysis of the light curves yields that the infrared echoes are sharp, while the Hα BLR echo is smeared. We discuss how far this supports an optically thick bowl-shaped BLR and dust torus geometry as proposed by Kawaguchi & Mori (2010) and Goad et al. (2012). The observed smeared echo of the BLR can be reproduced with BLR clouds located inside the bowl closely above the bowl rim and spread over many isodelay surfaces. If the BLR clouds shield the bottom of the bowl rim against radiation from the nucleus, the hot dust emission comes essentially from the top edge of the bowl. For small inclinations, the top dust edge forms a ring that coincides with a narrow range of isodelay surfaces, yielding the observed sharp dust echo. For 3C120, the scale height of the BLR increases with radial distance from the black hole, leading to a luminosity dependent foreshortening effects of the lag. We discuss implications and possible corrections of the foreshortening for the black hole mass determination and consequences for the lag (size) - luminosity relationships and the difference to interferometric torus sizes.

Tuesday
14:50

Using temporal variations of AGN emission line profiles to get indications on the structure of both the BLR and the dust torus

Johannes Esser, MPIA Heidelberg
esser@mpia.de

The formation processes and the exact appearance of the dust torus and broad line region (BLR) of Active Galactic Nuclei (AGN) are under debate. Theoretical studies show a possible connection between the dust torus and BLR through a common origin in the accretion disk. However observationally the dust torus and BLR are typically studied separately. NGC 4151 is possibly one of the best suited Seyfert 1 galaxies for a simultaneous examinations because of its high number of both photometric and spectroscopic observations in the past. We compare changes of the dust radius to shape variations of broad emission lines (BEL). While the radius of the dust torus decreased by almost a factor of two from 2004 to 2006 shape variations can be seen in the red wing of BELs of NGC 4151. These simultaneous changes are discussed in a dust and BEL formation scheme. Additionally, we use the BEL shape variations to assess possible cloud distributions, especially in azimuthal direction, which could be responsible for the observed variations. Our findings can best be explained in the framework of a dust inflated accretion disk. The changes of the BELs suggest that this dusty cloud formation does not happen continuously, and over the whole accretion disk, but to the contrary in spatially confined areas over rather short amount of times. We derive limits to the azimuthal extension of the observed localized BEL flux enhancement event.

Tuesday
15:10

The Inner Torus/BLR "Disconnection"

Martin Ward, Durham University, UK
martin.ward@durham.ac.uk

The dusty molecular torus (now in modified form) has been a key ingredient of unified AGN models for more than three decades. However, only relatively recently have attempts been made to integrate it within a holistic and self- consistent picture involving; the central heating source, the BLR and NLR (in particular the highly ionised coronal lines). To this end we report new results from the first near-infrared spectroscopic dust reverberation study of an AGN, namely NGC5548. We derive dust temperatures (hence luminosity weighted radii), which, when combined with observed small temperature changes (lag time radii), indicate an absence of dust in the region implied by the sublimation temperature. In fact, the hot dust appears to be further out by about an order of magnitude. A similar situation has been claimed for NGC4151, but based only on less constraining photometric data. Clearly we need to explain this apparent "gap" between the outer BLR and the innermost hot dust. We propose models invoking in situ heating from the BLR, and destruction of dust in this gap region by a wind, possibly associated with the coronal lines.

Rapid Reformation of the Innermost Dust Distribution in the Changing-Look AGN Mrk 590

Tuesday 15:30

Mitsuru Kokubo, Tohoku University
mkokubo@astr.tohoku.ac.jp

We examined long-term optical/near-infrared flux variability of a "changing-look" active galactic nuclei (AGN) Mrk 590 from 1998 to 2007 over which the AGN bolometric luminosity had decreased by a factor of ~ 100. We found that Mrk 590 had experienced sudden luminosity decrease during the short period from 2000 to 2001. Dust reverberation lag between V- and K-band light curves measured during the faint state (in 2003-2007) indicates that the dust torus innermost radius of Mrk 590 had become small ($R_{dust} = 32$ light-days) by the year 2004 according to the aforementioned significant decrease of the AGN luminosity. These observations suggest that the replenishment time scale of the innermost dust distribution of Mrk590 is less than 3 years, which is much shorter than the free fall time scale of the broad line region gas clouds. We suggest that the rapid replenishment of the dust distribution after the sudden decrease of the AGN luminosity can be accomplished by new dust formation in the broad line region gas.

A tidal disruption event in Arp 299 with much of its emission reradiated at infrared wavelengths

Tuesday 15:50

Seppo Mattila, University of Turku
sepmat@utu.fi

We have observed an extremely energetic and long-lasting transient source in the western nucleus of the luminous infrared galaxy (LIRG) Arp 299 that radiated over 1.5×10^{52} erg at infrared (IR) and radio wavelengths but was not luminous in the optical or X-rays. In Mattila et al. (2018, Science, 361, 482-485) we interpret this as a tidal disruption of a star by a supermassive black hole in the nucleus which also harbours a Compton-thick AGN. We find that the observed IR SED of the transients can most plausible be explained by reradiation by optically thick dust clouds in the polar regions of the AGN torus. We model the pre- and post-outburst IR SED of the nucleus using radiative transfer models (from Efstathiou et al.) for the emission from a starburst and from a dusty torus, including also the effects of dust in the polar regions and find a covering factor of the polar dust between 23 and 78%. Similar events have remained hidden within the dusty and dense nuclear environments and may be more frequent at higher redshifts where galaxy mergers and LIRGs are more common.

Tuesday
16:40

Insight on quasar changing-look physics from optical polarimetry

Damien Hutsemekers, University of Liège (Belgium)
d.hutsemekers@uliege.be

A handful of quasars changing from type 1 (strong broad and narrow emission lines) to type 1.9 (strong narrow lines only and dim continuum) on timescales of a few years have been recently uncovered. If the disappearance of the broad emission lines observed in changing-look quasars were caused by the obscuration of the quasar core through moving dust clouds in the torus, high linear polarization typical of type 2 quasars would be expected. We measured the polarization of the changing-look quasar J1011+5442 in which the broad emission lines have disappeared between 2003 and 2015. We found a polarization degree compatible with null polarization. This measurement suggests that the observed change of look is not due to a change of obscuration in a torus hiding the continuum source and the broad line region. Our results thus support the idea that the vanishing of the broad emission lines in J1011+5442 is due to an intrinsic dimming of the ionizing continuum source that is most likely caused by a rapid decrease in the rate of accretion onto the supermassive black hole. New polarization measurements have been secured for a sample of changing-look quasars. They essentially confirm our previous results.

Tuesday
17:00

The Dust Sublimation Region in Nearby AGN

Bella Boulderstone, University of Southampton
Bella.Boulderstone@soton.ac.uk

We present the first results of a monitoring campaign of twelve nearby AGN (Boulderstone et al., in prep). The goal of this campaign is to understand whether the dusty environment surrounding the black hole depends on the physical properties of the AGN, such as luminosity or accretion rate. Here, we probe the innermost hot dust sublimation region that supposedly follows a simple size - luminosity relation, $r \sim L^{1/2}$. Given the small size scales involved, we resolve the hot dust radius in the time domain by measuring the lag between the variability signal in the optical accretion disk emission and the near-infrared hot dust emission. We find these time lags to be consistent with the already established lag-luminosity relationship without indication of more complex dependencies. This implies relatively simple physics governing hot dust emission and sublimation with limited dependencies from the geometric distribution of the dust. We are now using this sample as the low-redshift basis to exploit the size-luminosity relation for cosmological applications as a standard candle in the course of the ESO public survey VEILS.

X-ray multi-epoch variability of the Low-Luminosity AGN NGC 1052

Tuesday 17:00

Natalia Osorio-Clavijo, Instituto de Radioastronomía y Astrofísica, UNAM
n.osorio@irya.unam.mx

It is stated that Low-Luminosity AGN are not well explained through the Unified Model because it is not well known if there is indeed an obscuration structure or if the accretion mechanism is intrinsically different. In this work we study the X-ray variability of NGC 1052, a prototype of Low-Luminosity AGN, for a period of 11 years, distributed in seven observations. These observations allow us to study intrinsic variations, related to the accretion disk, and the reflection component, which is believed to be directly correlated to the outer parts of the torus. This is the first time that, NuSTAR is reported to study this object, what allows us to restrict the torus component at X-rays. As for the spectral fit, we have found for this object shows variations in several parameters of these components. Through the talk we will discuss the implications of these complex variable nature, never seen before in a LLAGN with such a detail.

Investigating the nature and geometry of NGC 1068 through NuSTAR observations and future X-ray polarimetry

Tuesday 17:40

Alessandra Zaino, Roma Tre University
alessandra.zaino@uniroma3.it

After the first event observed in August 2014, during the last year NGC 1068 experienced a new Compton-thick unveiling episode, in which the nuclear radiation was able to pierce through the circumnuclear absorbing material. In the first part of the talk, I will discuss the constraints on the location and on the physical properties of the obscuring medium obtained from the spectral analysis of the latest NuSTAR monitoring campaign (July 2017 - February 2018). In the second part of the talk, I will discuss what we can infer on the nature and geometry of this source from future X-ray polarimetry missions, and in particular from the Imaging X-ray Polarimetry Explorer (IXPE), due to be launched in 2021.

Torus in its surrounding

Tuesday 9:00

Bipolar ionisation cones in nearby QSO2s: constraints on the torus

Thaisa Storchi-Bergmann, Instituto de Física - UFRGS - Brazil
thaisa@ufrgs.br

We have used narrow-band [OIII] and Hα Hubble Space Telescope (HST) images of luminous (L[OIII]>10^{42} erg/s) type 2 QSOs with redshifts 0.1<z<0.5 in order to constrain the geometry of their Extended Narrow-Line Regions (ENLR), as recent ground-based studies suggest they become more spherical at high luminosities due to destruction of the torus. We find instead elongated ENLRs reaching 4 to 19 kpc from the nucleus and bipolar ionization cones in [OIII]/Hα excitation maps indicating that the torus survives these luminosities. We use the available images and fluxes in order to obtain constraints on the properties of the torus. Combining our measurements with previous ones based on similar data, we have also revisited the relation between the ENLR radius and L[OIII] over the range 39<log(L[OIII])<43.5 (L in erg/s).

Wednesday 9:30

The star formation – AGN link on 100 pc scales: Stellar populations in the nuclei of ultra hard X-ray selected AGNs

Leo Burtscher, Leiden Observatory
burtscher@strw.leidenuniv.nl

Some models see the outflows from evolved stars as the building material of AGN tori. In this picture, inflow of molecular gas into the circum-nuclear regions first causes a burst of star formation before feeding the super-massive black hole, via the dusty torus. In this project, we wanted to test this model in a rigorously selected sample of the most luminous local AGN and matched inactive control galaxies (the LLAMA sample). Here we present the nuclear (R $\approx$ 100 pc) star formation histories of this sample. Using VLT/X-SHOOTER spectroscopy, we performed stellar population synthesis of ten AGNs and 17 inactive control galaxies. We find that the nuclear star formation histories of AGNs are in general very similar to the star formation histories of inactive galaxies. The stellar populations of AGNs are slightly more similar to those of nuclear star-forming galaxies than to those of passive galaxies. This supports the view that AGNs are not characterised by a special nuclear stellar population, but that AGN activity is an inevitable (and stochastically variable) consequence of a gas-rich nuclear environment.

BAT AGN prefer circumnuclear star formation

Wednesday 9:50

Dieter Lutz, Max-Planck-Institut für extraterrestrische Physik
lutz@mpe.mpg.de

We use Herschel to derive the size of the FIR emitting region in large samples of local galaxies, and study scalings of size and surface brightness with FIR luminosity, distance from the main-sequence, and FIR color. Comparing BAT AGN with reference galaxies, we find large scatter of half light radii for both, but a typical value for the BAT hosts that is only half that of comparison galaxies of same FIR luminosity. Our findings are in support of an AGN-host coevolution where accretion and star formation are fed from the same gas reservoir, with more efficient BH feeding if that reservoir is more concentrated. The significant scatter in the far-infrared sizes emphasizes that we are mostly probing spatial scales that are much larger than those of actual accretion, and that rapid accretion variations can smear the distinction between the AGN and comparison categories. Large samples are hence needed to detect structural differences that favor feeding of the black hole.

Does star formation play a decisive rolein active galactic nuclei fueling?

Wednesday 10:10

Rogério Riffel, Astronomy Department, Federal University of Rio Grande do Sul, Brazil
riffel@ufrgs.br

Active Galactic Nuclei (AGN) characterize a critical phase in galaxy evolution in which its nuclear supermassive black hole (SMBH) is being fed due to gas accretion onto the nuclear region. The AGN feeding and feedback processes are believed to couple the growth of the SMBHs and their host galaxies, and are claimed to be responsible for the correlation between the mass of the SMBH and that of the galaxy bulge. The co-evolution scenario, and the gas feeding in the inner kiloparsec of galaxies when they are in the active phase implies that the galaxy bulge grows in consonance with the SMBH. Over the last few years, our team has undertaken a major observational effort to understand this co-evolution by recovering the spatially resolved star formation history and studying the stellar kinematics of the inner few tens parsecs of galaxies. To this purpose we are applying an updated version of the STARLIGHT code to Gemini Near-infrared Integral Field Spectrograph (NIFS) data-cubes of nearby Seyfert galaxies. We found rings of intermediate-age stars, being correlated with low stellar velocity dispersion values, interpreted as being originated by stars that still preserve the kinematics of the gas from which they formed. Hot dust emission was detected nearly 80% of the galaxies accounting for 20-90% of the observed K-band nuclear flux. A featureless (FC) component was detected, contributing with ∼25

Wednesday
11:20

The complex nuclear regions of young radio galaxies

Raffaella Morganti, ASTRON/Kapteyn Institute, Groningen (NL)
morganti@astron.nl

A clear outcome of the wealth of new observations able to trace the gas down to the inner few tens of pc of an AGN, is that the dusty torus doesn't live in isolation. A complex interplay of outflowing gas and infalling clouds, observed using the cold (molecular and HI) gas must, not only influence the structure of the central torus and the reservoir of gas but also the obscuration in the central region. Furthermore, the conditions of this surrounding medium may also change as the AGN evolves. We will present the results from high resolution observations (milliarsec, i.e. up to tens of pc scale) of the cold molecular and HI gas in the centre of radio AGN. Our work uses Very Long Baseline Interferometry (VLBI) and ALMA observations and we are focusing on radio galaxies with young (i.e. only recently started or re-started) radio jets. In addition to the presence of regularly rotating circumnuclear tori/disks, we find - on regions smaller than a few tens of pc - signatures of gas fuelling the AGN (including isolated clouds consistent with the prediction of chaotic cold accretion) as well as of fast AGN-driven outflows. Outflows of up to 100 $M_{\odot}$/yr have been found in molecular gas on scales of only tens of pc from the SMBH. At the same time, the HI is showing that fast outflows observed on these scales are clumpy, as predicted by numerical simulations. Our data allow to start building up a picture of the relevant physical processes in the heart of young radio AGN and how they connect with the presence and characteristics of the circumnuclear tori/disks.

Wednesday
11:45

Obscuration Beyond the Torus: Assessing AGN Environments and Obscuration as a Function of Merger Stage

Ryan Pfeifle, George Mason University
rpfeifle@masonlive.gmu.edu

For the past 3 decades, the so-called dusty torus has been considered a vital component of AGN unification schemes, and its impact on obscuration of the AGN has been well-studied. However, it is now clear that gas and dust within the host galaxy can play a significant role in obscuring the central engine, particularly in late-stage galaxy mergers, when the black hole is expected to experience its maximum growth. In this presentation, I will compare the intrinsic absorption obtained through X-ray and MIR observations in a well-defined and well-studied sample of mergers with an arsenal of multiwavelength data, as a function of merger stage, compared to a control sample of isolated galaxies.This study will allow us to assess the importance of obscuration that is independent of the so-called dusty torus, and is critical to providing confirmation that the epoch of peak black hole growth in mergers occurs in a highly obscured phase.

An extreme population of heavily buried AGN: Identification and host galaxy characteristics

Wednesday
12:05

Christopher Carroll, Dartmouth College
christopher.m.carroll.gr@dartmouth.edu

Obscured quasars represent a large fraction of the total number of powerful active galactic nuclei (AGN). Understanding the complete quasar population requires a full accounting of these sources, which is difficult in the presence of complex selection effects. Additionally, dust extinction in obscured quasars allow us to observe their host galaxies and make connections between AGN emission and physical properties of their hosts. Using optical to mid-IR broadband photometry from SDSS, UKIDSS, and *WISE*, we model the spectral energy distributions (SEDs) for these systems with no prerequisite AGN selection and uncover dozens of powerful obscured quasars which lack hard X-ray counterparts in *NuSTAR* survey and serendipitous fields. At the *NuSTAR* flux limits, a lack of detection indicates extremely heavy obscuration with hydrogen column densities beyond $10^{25}\,\mathrm{cm}^{-2}$. This points to a population of very deeply buried AGN. We explore the host galaxy properties of these AGN and compare to similar samples with lower obscuration to investigate connections between level of obscuration, host galaxy environment, and AGN fueling.

Dynamics

Thursday
9:00

The "Torus" of NGC 1068: The ALMA View

Jack Gallimore, Bucknell University
jgallimo@bucknell.edu

I will review ALMA observations of the torus of NGC 1068 and present new, 20 mas (1.4 pc) resolution observations of HCN J=3-2. The new observations probe the boundary between broad-line region, the water megamaser disk, and the high velocity molecular outflow. I will discuss constraints on the geometry, kinematics, and gas conditions in the molecular torus.

Thursday
9:30

Investigating Sub-parsec Structure of Molecular Gas in AGN with H2O Megamasers

Jim Braatz, NRAO
jbraatz@nrao.edu

Water vapor masers at 22 GHz have been detected in nearly 200 galaxies, most of them nearby AGNs. VLBI observations of these masers provide direct mapping of molecular gas structures on sub-parsec scales. About 40 of these maser systems show evidence that they originate in circumnuclear disks, either by direct imaging or indirect spectral characteristics. These disks are viewed edge-on and appear remarkably thin, are sometimes warped, and in many cases have precise Keplerian rotation profiles. Disk megamasers have only been detected so far in type 2 AGNs, suggesting the thin maser disk aligns with the obscuring structure that hides the BLR. Apart from the disk masers, some megamaser systems reveal outflows or other structures that are complex both in morphology and in kinematics. In addition to the 22 GHz masers, sub-millimeter water megamasers have recently been detected in several galaxies with ALMA. These detections are opening new opportunities to study masers excited at different temperatures and densities, and may eventually provide a more complete picture of the structure of molecular gas in the nuclei of these AGNs.

A radio absorption study of AGN tori

Thursday 9:55

Seiji Kameno, JAO / NAOJ

seiji.kameno@alma.cl

An AGN torus is a reservoir of accretion matter and considered to be composed of dust, molecular gas, and plasma. Radio observations of a torus delivers rich information such as molecular species, column density, excitation states, kinematics, etc. In radio galaxies, the torus can be probed via absorption lines and plasma free-free absorption. Here I present a case study of NGC 1052, the nearby (20 Mpc) radio galaxy, observed using ALMA and VLBI. This object emanates twin symmetric jets and the torus is supposed to be seen edge-on. Our ALMA observations identified molecular absorptions features of CO, HCN, HCO+. CS, CN, SO, and possible SiO ascribed to the molecular torus, together with CO emission in 100-pc-scale circumnuclear disk. All of absorption features indicate infall motion toward the central engine. Together with VLBI observations of free-free absorption and H2O masers, I'll discuss about structure of the torus.

The dusty molecular torus of Seyfert galaxies is full of surprises

Thursday 10:20

Almudena Alonso-Herrero, Centro de Astrobiologia (CSIC-INTA)

aalonso@cab.inta-csic.es

In 2016 ALMA imaged for the first time the dusty molecular torus of the archetypical Seyfert 2 galaxy NGC1068. The first surprise was the relatively large size measured from the cold molecular gas and dust observations compared with the compact size derived from mid-infrared interferometry. Now a couple of years later, we confirm that the obscuring torus of nearby galaxies Seyfert galaxies is large, typically 20pc across, massive (molecular gas masses 10^6-10^7 Msun), and well connected with the host galaxy disk. Moreover, the torus is not a static rotating structure but it is also outflowing along both the equatorial and vertical directions. In this talk I will present the latest results from our on-going ALMA program for a sample of X-ray selected nearby Seyfert galaxies.

Thursday
11:20

The many 'faces' of the molecular torus of NGC1068

Santiago Garcia-Burillo, Observatorio Astronómico Nacional (OAN)-Spain
burillo@oan.es

We have used ALMA to image with ∼0.03-0.04"(2-3pc) spatial resolution the emission of a set of molecular lines, including CO(2-1), CO(3-2) and HCO+(4-3), and their underlying continuum emission in the circumnuclear disk of NGC1068, covering a region that extends from r∼200pc down to the central 7-10pc-diameter torus of this prototypical Seyfert 2 galaxy, which was first detected in the 6-5 line of CO by García-Burillo et al 2016. These new observations, by using three lines spanning three orders of magnitude in densities, reveal the many 'faces' of the molecular torus in NGC1068. The torus shows a stratified layered structure spanning a radial range that goes from r∼2-3pc to r∼10pc. The kinematics of molecular gas in the torus are characterized by strong non-circular motions and enhanced turbulence. Furthermore, the CO(2-1) line emission has allowed us to image the outflowing molecular gas component emerging from the torus. A far-reaching question, to be answered by ongoing ALMA surveys of nearby AGNs (NUGA, GATOS), is whether similarly perturbed and turbulent tori are expected to be found ubiquitously in Seyfert galaxies, and if their properties should change as a function of parameters like the AGN luminosity, the degree of obscuration, or the Eddington ratio.

Thursday
11:45

The counter rotating molecular torus in NGC1068

Violette Impellizzeri, NRAO/ALMA
violette.impellizzeri@alma.cl

We present here results obtained with ALMA on the prototypical Seyfert 2 nucleus in NGC 1068. Previous CO (6-5) observation already showed evidence for a high-velocity outflow at a resolution of ∼ 0.04" resolution. We have now obtained data with a factor ∼ 2 better resolution (∼1 pc-scale) with the most extended ALMA configurations. We observed HCN J=3-2 to reveal a P-Cygni line profile against the radio nucleus, consistent with the outflow observed in CO. The projected radial velocity of this molecular outflow is ∼170 km/s with high velocity wings ranging up to 400 km/s. The nuclear spectrum also shows a narrow, redshifted absorption component at infall speed ∼40 km/s. Analysis of the position-velocity diagram and the morphology of the integrated line flux map reveals two nested, rotating disk components. The inner disk, inside ∼ 1.5 pc, has kinematics consistent with the edge-on, geometrically thin H2O water megamaser disk. The outer disk, which extends to 7 pc, is also geometrically thin but inclined. The outer disk counter-rotates relative to the inner, water megamaser disk. We conclude that the torus consists of two geometrically thin, counter-rotating disks, and the nuclear obscuration occurs in outflowing molecular clouds whose origin is likely a hydromagnetic wind driven off of the inner disk.

ALMA reveals a rotating dense molecular torus in NGC 1068

Thursday 12:05

Masatoshi Imanishi, NAOJ
masa.imanishi@nao.ac.jp

The unification paradigm of AGNs postulates that a dusty molecular torus is present around a mass accreting supermassive black hole (SMBH), in order to naturally explain the presence of type-1 AGNs (which show broad optical emission lines) and type-2 AGNs (which do not). This paradigm was proposed from the observation of the nearby type-2 AGN, NGC 1068. However, our observational understanding of the torus of AGNs has been incomplete, even including the prototypical AGN NGC 1068, simply because the torus is spatially compact, say <10 pc in physical scale or <0.15" at the distance of >10 Mpc. We present the results of our very high-spatial-resolution (0.04 × 0.07") ALMA observations of the NGC 1068 nucleus in the HCN J=3-2 and HCO+ J=3-2 emission lines, which are expected to probe dense molecular gas in the torus. In NGC 1068, the optical [OIII] emission and radio jet are elongated along the north-south direction from the mass-accreting SMBH. Thus, the putative torus in NGC 1068 is expected to be aligned roughly along the east-west direction. Previous ALMA high spatial resolution CO J=6-5 observations by two independent groups found north-south oriented dynamical properties, which are difficult to interpret within the torus paradigm and are possibly contaminated by outflowing molecular gas along the polar direction of the torus. In the HCN J=3-2 and HCO+ J=3-2 lines, we have for the first time clearly detected the dense molecular gas emission oriented along the east-west direction both morphologically and dynamically. Our observational results conform to the classical torus picture in NGC 1068. We also found that the torus dense molecular gas properties are more complicated than those predicted by the simple classical torus picture. Namely, (1) molecular emission from the torus is not axi-symmetric, (2) the dense molecular gas in the torus is counter-rotating with respect to that outside the torus in the host galaxy, and (3) the rotation speed is significantly slower than that expected from a pure Keplerian motion governed by the central SMBH with an estimated mass of 1×10^7 solar masses. We present these observational results and future prospect to better understand the nature of the torus in NGC 1068.

NUclei of GAlaxies (NUGA) resolved by ALMA

Thursday 12:25

Anelise Audibert, Observatoire de Paris
anelise.audibert@obspm.fr

Our aim is to explore the close environment of AGN and the dynamical structures leading to its fuelling, through the morphology and dynamics of the gas inside the sphere of influence of the black hole, in order to test the various possible phases of evolution for the molecular tori. We report ALMA observations of a sample of 7 Seyfert/LINER part of the NUGA (NUclei of GAlaxies) project, at the unprecedented spatial resolution of 0.06-0.09" (3-10 pc). We will present the observed molecular maps that have revealed the existence of molecular tori in about half of the sample, with varying orientation along the line of sight, unaligned with the orientation of the host galaxy. We will show AGN feeding and feedback caught in action in some cases: trailing spirals observed inside the central 100 pc and the detection of molecular outflows. Additionally, we will present the tori parameter space derived from the near IR to sub-millimetre SED fitting by using torus emission models that take into account the polar mid-IR emission, seen in many nearby AGN (CAT3D-WIND).

Thursday
14:30

Circumnuclear Multi-phase Gas in the Circinus Galaxy Revealed with ALMA

Takuma Izumi, National Astronomical Observatory of Japan
takuma.izumi@nao.ac.jp

We used the Atacama Large Millimeter/Submillimeter Array (ALMA) to map the CO(3-2) and [C I](1-0) lines, as well as their underlying continuum emissions, from the central ∼200 pc region of the Circinus galaxy that hosts the nearest active galactic nucleus (AGN), with a spatial resolution of ∼6-15 pc. The lines and continuum-emitting regions consist of the ∼70 pc scale circumnuclear disk (CND) and spiral arms. The distribution of the continuum emissions revealed a temperature-dependent dust geometry and polar dust elongation in the torus region. The beam-averaged H2 column density is ∼5x10^{23} cm^{-2} toward the AGN position, which contributes significantly to the nuclear obscuration. We decomposed the observed velocity field into rotational velocity and velocity dispersion, and revealed multi-phase dynamic nature in the r < 10 pc torus region. The diffuse atomic gas is more spatially extended along the vertical direction of the disk than the dense molecular gas there. Through detailed comparisons with our model predictions based on the radiation-driven fountain scheme, we indicate that atomic outflows are the driver of the geometrical thickness of the atomic disk. This supports the validity of the radiation-driven fountain in the vicinity of this AGN, which would explain a long-lasting mystery of the physical origin of the AGN torus.

Thursday
14:50

The compact molecular torus in the Circinus galaxy constrained by ALMA

Konrad Tristram, ESO
konrad.tristram@eso.org

With ALMA it is now possible to probe the cold dust emission as well as the kinematics of the molecular component obscuring material in AGN on prasec scales. However, the first results for NGC1068 have been rather contradictory with respect to the dominating kinematics in the "torus". In my talk, I will present the results of our ALMA observation of the core of the Circinus galaxy, revealing that the submm counterpart of the torus is very compact, not much larger than the structures detected in the infrared. We detect emission from CO(6-5), CO(3-2), HCO+(4-3), HCN(4-3) lines, as well as very weak CS(7-6). The CO(3-2) emission does not show any concentration toward the nucleus defined by the continuum peak, but rather a hole. CO(6-5) as well as the other high density gas tracers on the other hand are clearly concentrated towards the nucleus, indicating that the gas is excited to higher transitions at the very nucleus. Fitting a simple disk model to the data, we find the kinematics to be dominated by rotation, with no clear signs of an outflow. This is somewhat in contradiction to the dusty wind models proposed to explain the polar elongated dust structures seen in the mid-infrared.

A new dynamical model of AGN tori

Thursday 15:10

Chi-Ho Edwin Chan, Hebrew University of Jerusalem and Tel Aviv University
chi-ho.chan@mail.huji.ac.il

We introduce a new dynamical inflow–outflow torus model to complement existing phenomenological outflow torus models. We demonstrate how our latest radiative magnetohydrodynamics simulations inform this model, which includes a high-latitude, wide-angle outflow launched from the inner edge and a denser midplane inflow continuously feeding it. We discuss potential observational signatures of the inflow and the outflow. We also touch on the implications the outflow has on the dynamical state of the inflow.

Dynamical pictures of tori and the multi-phase ISM

Thursday 15:35

Keiichi Wada, Kagoshima University
wada@astrophysics.jp

I review recent radiation hydro and magneto-hydrodynamic simulations on a torus scale to clarify difference from the classical static picture of the torus. I will also review some recent results of comparison between numerical models and observations.

Hydrodynamical models of obscuring accretion disks and winds

Thursday 16:30

A. Dorodnitsyn, NASA Goddard Space Flight Center
dorodnitsyn@gmail.com

We present results from numerical simulations of a parsec-scale torus exposed to illumination by an accretion disk in active galactic nucleus (AGN). Our first group of models assess the role of radiation pressure on dust in shaping the torus and counterbalancing the accretion inflow, without resorting to magnetic fields. The results demonstrate that radiation pressure on dust can play an important role in shaping AGN obscuration. For example, when the luminosity of AGN exceeds 0.1 $L_{\rm Edd}$, we find that radiation pressure on dust can almost stop accretion. Interestingly, the accretion in this case still proceeds at a rate 10^{-4} to 10^{-1} $M_\odot$/yr via capturing of the gas from the hot evaporative flow thus providing a mechanism to deliver gas from a radiation–pressure dominated torus to the inner accretion disk. The second group of models addresses the role of large-scale magnetic field in shaping the torus, implying a scenario when loops of large-scale field are dragged from the galactic disk, along with inflowing gas. Our 3D MHD simulations have many shared features with corresponding simulations of geometrically thick accretion disks. The results suggest that magnetic field further complicates an interplay between accretion and winds in the torus region. The magnetic field provides a mechanism to redistribute angular momentum through MRI turbulence and outflows. Models with strong initial poloidal filed evolve into a

configuration that resembles the arrested disk with a strongly magnetized torus funnel. External X-ray irradiation does not qualitatively change the results. However, extensive heating does shift the outcome to a more turbulent and irregular torus, as a result of enhanced convection.

Thursday
16:55

Radiative hydrodynamics of dust and gas in the "torus"

David Williamson, University of Southampton
d.j.williamson@soton.ac.uk

Recent high resolution observations suggest a that the "torus" region is dynamically and geometrically more complex than previously assumed. Hence, novel models are required to explain the radiative and dynamical properties of the circumnuclear environment. We have developed a new radiation-hydrodynamics model of the "dusty torus". We take a new approach by using Lagrangian hydrodynamics to better capture the dynamical nature and high density contrast in the region. A key element of the new code is a raytracing radiation model that focuses on accurately simulating the effects of radiation pressure in the inner wind-producing region, without making the flux-limited diffusion or reduced speed of light assumptions. We will present our latest results from these simulations, showing a two-phase structure: An equatorial disk/"torus" characterised by cool and dense dusty gas and a low-density wind driven of the inner part of the disk. The dynamics of the "torus" and wind can be used to simultaneously explain the extended polar emission detected in infrared interferometry, as well as the rotation inferred from sub-mm molecular emission lines and the dynamics of H2.

Thursday
17:15

Simulating nuclear fueling in realistic environments

Daniel Angles-Alcazar, Flatiron Institute
danglesalcazar@flatironinstitute.org

Modeling nuclear fueling in a full cosmological context is a crucial step towards understanding the nature of black hole-galaxy co-evolution. Recent progress from cosmological hydrodynamic simulations has been limited by resolution, interstellar medium physics, and the treatment of black hole accretion. In this talk, I will present results from the Feedback In Realistic Environments (FIRE) project, where supernovae, stellar winds, and radiation are implemented at the scale of star-forming regions, showing that bursty stellar feedback regulates the gas reservoir in galactic nuclei and can severely limit early black hole growth. I will then present ongoing work on cosmological hyper-refinement simulations that for the first time resolve the formation of dense obscuring structures at $\sim$pc scales around the central black hole in a realistic multi-phase interstellar medium.

Molecular Gas in the Nuclear Regions of Nearby Dual AGN

Thursday 17:35

Ezequiel Treister, Pontificia Universidad Catolica
etreiste@astro.puc.cl

Major galaxy mergers hosting two supermassive black holes (SMBHs) actively growing separated by less than 10 kpc, the so-called dual active galactic nuclei (AGNs) are ideal targets for understanding SMBH feeding, obscuration, and testing unification models and galaxy evolution. In this talk, I will present the main results from our program aimed to obtain optical and near-IR Integral Field Unit (IFU) spectroscopy and ALMA maps for a sample of confirmed nearby dual AGN. In addition to providing general properties of this population, I will focus on two remarkable systems, NGC6240 and Mrk 463. At a distance of 210 Mpc, and a nuclear separation of ∼4 kpc, Mrk 463 is an excellent laboratory to study the gas dynamics, star formation processes and SMBH accretion in a late-stage gas-rich major galaxy merger. The optical data, which map the full extent of the merger, show evidence for a biconical outflow and material outflowing at ¿600 km/s, both associated with the east nucleus, along with large-scale gradients likely related to the ongoing galaxy merger. The ALMA observations of 12CO(2–1) and adjacent 1 mm continuum reveal the presence of ∼1e9Mo in molecular gas in the system. The molecular gas shows velocity gradients of ∼800 km/s and ∼400 km/s around the Mrk 463E and 463W nuclei, respectively. We conclude that, in this system, the infall of ∼100s Mo/yr of molecular gas is in rough balance with the removal of ionized gas by a biconical outflow being fueled by a relatively small, <0.01% of accretion onto each SMBH. I will further present highest resolution maps of the merging galaxy system NGC6240, which hosts two SMBH growing simultaneously. At 0.03" (15 pc), the ALMA 12CO(2-1) observations are a perfect match for existing Hubble optical and near-IR observations of this system. We find that most of the molecular gas is found in between the two nuclei but forming a clumpy stream and not a smooth rotating disk, as was previously assumed based on lower resolution data. A clear velocity gradient suggests that the molecular gas is getting ready for the next stage, in which it will coalesce around each nuclei and become available to significantly increase the amount of accretion onto each SMBH. We further detect the presence of significant high velocity, >500 km/s, outflows, responsible for the removal of a fraction of the material. These results clearly show the importance of performing high resolution multi wavelength studies covering pc to kpc scales in order to understand the complex connection between black hole growth and galaxy evolution in this critical phase.

Evolution & Parameter Space

Friday 9:00

Nuclear obscuration properties in AGN

Cristina Ramos Almeida, Instituto de Astrofísica de Canarias
cra@iac.es

In the past 10-15 years our view of the obscuring torus has completely changed thanks to the combination of new observations and models. X-ray, infrared and sub-mm data have been crucial to peer into the inner region of AGN and study the properties of the nuclear obscurer, albeit several questions remain. In this review I will summarize our current view of nuclear obscuration in AGN, focusing on the variations of the torus properties with e.g. luminosity, evolutionary state, and gas phase. I will also discuss possible paths and future instrumentation that can contribute to our knowledge of the obscuring material.

Friday 9:30

Constraints on the Properties of the Torus from the NuSTAR Survey of Nearby Obscured AGN

Mislav Baloković, Harvard University
mislav.balokovic@cfa.harvard.edu

In this talk I will present results from a broadband X-ray study of the geometrical properties of the AGN torus in a large and representative sample of type II Seyfert nuclei. The sample consists of 130 AGN selected in the hard X-ray band from the Swift/BAT 70-month catalog and observed simultaneously with NuSTAR and Swift/XRT. Making use of the newly developed libraries of theoretical spectral templates, the basic parameters of AGN tori – the covering factor and the globally averaged column density – have been recently constrained using this sample. The distribution of torus covering factors is broad but shows a preference for high covering, peaking around the covering factor of 90%, with the median at 70%, in agreement with recent sample studies in the infrared band. It was also found that the covering factor depends non-monotonically on intrinsic luminosity, so that the median covering factor peaks around the intrinsic X-ray luminosity of $10^{42.5}$ erg/s and decreases toward both lower and higher luminosities. I will also outline a path toward improving these constraints from the X-ray band, and toward constraining the size, clumpiness, dynamics, and relation of the torus to the rest of the accretion flow.

Resolving X-ray Obscuration Biases with Isotropic AGN Selection – First Results from the NuLANDS Legacy Survey

Friday 9:55

Peter Boorman, University of Southampton
P.G.Boorman@soton.ac.uk

An accurate assessment of the Compton-thick fraction amongst local AGN provides important insights into the composition and structure of AGN X-ray obscuration, as well as its connection with the typical torus and broad line region. However, current estimates of the Compton-thick fraction vary dramatically between ∼20-70%, and it remains unclear whether this large range is driven by selection effects, inadequate sample sizes, luminosity/Eddington rate dependencies or something else entirely. The main handicap of previous works has been the inability to select a *representative* sample of the entire AGN population, unbiased by Compton-thick obscuration or radiative efficiencies. To investigate such issues, we present NuLANDS - a large legacy survey with the X-ray satellites NuSTAR, XMM-Newton and Swift (more than 4 Ms in total) aimed at constructing an unbiased census of AGN obscuration in the local Universe. The far-infrared sample selection based around AGN-like colours guarantees that we are not affected by line-of-sight X-ray obscuration biases, even into the $\log N_{\rm H}/{\rm cm}^{-2} > 25$ regime. In this talk, I will report on multiple new Compton-thick AGN discovered and classified with NuLANDS, complemented with multi-wavelength diagnostics. First results further indicate a Compton-thick fraction $> 30\%$ and that hard X-ray selection alone remains biased against the most heavily obscured AGN. NuLANDS marks a major step in completing the local census of accretion activity, and will provide vital boundary conditions for determining the composition of the Cosmic X-ray Background, as well as insights into the densest regions of the AGN torus.

Reflection and Reprocessing in Swift/BAT AGN: Evidence of a Broad Range of Covering Fractions?

Friday 10:15

Lauranne Lanz, Dartmouth College
lauranne.lanz@dartmouth.edu

One of the outstanding questions about AGN structure is the range and distribution of the covering fractions. We investigated this question using the sample of 69 Swift/BAT AGN with hard X-ray spectra from NuSTAR and IR spectral energy distribution from Herschel and WISE. We find a correlation between hard X-ray reflection and the IR emission, suggesting both of these emissions are due to processing of the intrinsic emission from the corona and accretion disk by the same structure. Since the degree of reprocessing could be related to the covering fraction, we created a range of models for the distribution of the covering fraction and determined which types result in observables consistent with our data. We find that broad distributions centered around a covering factor of at least 40% match our observations best. I will discuss this new methodology for exploring the covering fraction distribution of Swift-BAT AGN and its implications for the torus structure.

Friday 11:20

The Effect of Extended Hard X-ray Emission on AGN Torus Parameters

Martin Elvis, Harvard-Smithsonian Center for Astrophysics
melvis@cfa.harvard.edu

The Chandra discovery that as much as 30% of the hard ($>$ 3 keV) continuum and the narrow 6.4 keV Fe Kα emission of Compton Thick (CT) AGN can come from kiloparsec scale regions along the ionization cone (Circinus, Arevalo et al 2014; NGC1068, Bauer et al 2015; ESO428-G014, Fabbiano et al., 2017, 2018), challenges the normal assumption that reflection from the torus is the source of both components (e.g. Netzer 2015; Asmus et al 2015). If not taken into account, this will bias the derived torus parameters toward, e.g., larger covering factors and/or grazing incidence angles across the top of the obscuring torus to match the artificially high reflection implied. In addition the extended hard X-ray emission can constrain the torus parameters. At a minimum, the Chandra-imaged opening angle should not be larger than the spectrally implied opening angle. The lack of hard extent in NGC7582, which has fc$\sim$0.9, is encouraging. We report on these large, hard extended regions and their effects on derived torus parameters using the Compton hump model of Balokovic' et al. (2017).

Friday 11:40

Survival of the obscuring torus in the most powerful active galactic nuclei

Silvia Mateos, Instituto de Física de Cantabria
mateos@ifca.unican.es

Dedicated searches suggest that the fraction of obscured Active Galactic Nuclei (AGN) decreases substantially with increasing luminosity. To explain these findings receding torus models have often been adopted. I shall present the results of a recent study where we determined the intrinsic fraction of optical type-2 AGN at z$<$1 and over three decades in X-ray luminosity. We used a complete X-ray selected sample of 199 AGN, from the Bright Ultrahard XMM-Newton Survey, and the distributions of covering factors of AGN tori derived from CLUMPY torus models. Since these distributions combined over the total AGN population need to match the intrinsic type-2 AGN fraction, we revealed a population of X-ray undetected objects with high-covering factor tori, which are increasingly numerous at higher AGN luminosities. When these "missing" objects are included, we found that the intrinsic type-2 AGN fraction is $\sim$58% and has a weak, non-significant luminosity dependence. Our findings imply that the majority of luminous rapidly-accreting supermassive black holes at z$<$1 reside in highly-obscured nuclear environments but most of them are so deeply embedded that they have so far escaped detection in $<$10 keV wide-area X-ray surveys

Probing the Nature of the Obscuring Torus via Megamaser Activity

Friday 12:05

Anca Constantin, James Madison University
constaax@jmu.edu

If water megamaser disk activity is, as suspected, intimately related to the circumnuclear toroidal obscuration of actively accreting supermassive black holes, a thorough understanding of the co-evolution of galaxies with their central black holes should consider the degree to which the maser production and properties correlate with those of their host galaxies. This contribution presents a novel comparative investigation of multiwavelength nuclear and host properties of galaxies with and without water megamasers, with results that reveal a rather narrow multi-dimensional parameter space associated with the megamaser disk emission. This "goldilocks" region embodies the availability of gas, the degree of dusty obscuration and reprocessing of the central emission, the age of the associated stellar population, the accretion rate, the black hole mass, and their environments. These findings suggest that the disk megamaser emission is linked to a particular short-lived phase in the intermediate-mass galaxy evolution, implying that the existence and properties of the dusty torus also reflect evolutionary changes. This brings new and independent support to the idea that quantifying the type 1-2 AGN dichotomy is not merely a function of inclination, but must involve the growth process of the incumbent AGN and its host galaxy.

BASS Survey: The Covering Factor of Dust and Gas in Swift/BAT AGN

Friday 12:25

Kohei Ichikawa, Columbia/Tohoku University
k.ichikawa@astr.tohoku.ac.jp

We quantify the luminosity contribution of active galactic nuclei (AGN) to the 12 um, mid-infrared (MIR; 5-38 um), and the total IR (5-1000 um) emission in the local AGN detected in the all-sky 70-month Swift/Burst Alert Telescope (BAT) ultra hard X-ray survey. We decompose the IR spectral energy distributions (SEDs) of 587 objects into the AGN and starburst components using AGN dust and star-forming galaxy templates. This enables us to recover the AGN dust emission including the low-luminosity end, down to log L(14-150 keV)$\sim$41, which typically have significant host galaxy contamination. The sample demonstrates that the luminosity contribution of the AGN to the 12 um, the MIR, and the total IR band is an increasing function of the 14-150 keV luminosity. The obtained total IR AGN luminosity through the IR SED decomposition enable us to estimate the fraction of the sky obscured by dust, i.e., the dust covering factor. We demonstrate that the median of the dust covering factor is always smaller than that of the X-ray obscuration fraction above the AGN bolometric luminosity of log Lbol $\sim$ 42.5. Considering that X-ray obscuration fraction is equivalent to the covering factor coming from both the dust and gas, it indicates that an additional neutral gas component, along with the dusty torus, is responsible for the absorption of X-ray emission.

Future opportunities

Friday
14:30

Opportunities with the James Webb Space Telescope

Nancy Levinson, STScI
nlevenson@stsci.edu

I will provide an update on the status of the James Webb Space Telescope and describe some opportunities it provides to answer outstanding questions related to the AGN torus. JWST offers multiple infrared imagers and spectrographs, including integral field units, for high-sensitivity and high-resolution observations. The JWST proposal process is "single-stream," requiring specification of the complete observing program in advance. A number of tools and resources are available to help users complete this process.

Friday
14:50

What optical long-baseline interferometry can do for you

Walter Jaffe, Leiden Observatory
jaffe@strw.leidenuniv.nl

The Very Large Telescope Interferometer is by far the most successful facility so far to actually resolve the parsec-scale dusty torus in nearby AGNs. The newly commissioned second generation mid-infrared instrument MATISSE will soon allow us to increase its resolution in the thermal infrared three-fold, while also recording closure phases and therefore allowing us to reconstruct actual images of the dust distribution in the central parsecs of AGNs. In this talk we present the technical capabilities of MATISSE, with a particular emphasis on its use for studying the AGN torus. We will cover the sensitivity limits (and what sets them), the number of accessible sources (and which ones will be observed in the GTO programme) and discuss a number of upcoming upgrades to the VLTI, most notably NAOMI (Adaptive Optics on the small telescopes) and Gra4Mat (using GRAVITY as a fringe tracker for MATISSE).

ELT/METIS and the torus

Friday
15:15

Leonard Burtscher, Leiden Observatory
burtscher@strw.leidenuniv.nl

The Mid-infrared E-ELT Thermal Infrared imager and Spectrograph (METIS) is one of the three first-light instruments selected for the European Extremely Large Telescope (ELT) and will cover the entire thermal infrared wavelength range, from ca. 3 - 20 microns in the terrestrial L, M, N and Q bands. It will be a versatile instrument featuring diffraction-limited imaging and long-slit spectroscopy in the L/M and N/Q bands as well as high spectral resolution (R 100,000) integral field spectroscopy in the L and M bands. Its spatial resolution of 25 (70) mas in the L (N) band corresponds to a linear scale of 1 (3) parsec in nearby (10 Mpc) galaxies. For nearby AGNs, METIS forms the missing link between JWST and ground-based interferometry in both resolution and sensitivity. METIS will primarily observe continuum emission from dust at 100-800 K, but it also sensitive to the emission lines in its wavelength range, e.g. Brackett alpha, coronal lines like [SiIX] and [ArVI] and [AlVI], molecular lines of CO and H2O, and broad silicate emission and absorption lines. As such it is well matched to tackle several of the big outstanding questions in current AGN research including "What triggers AGN activity?" and "How do AGN outflows connect to the host galaxy?".

Opportunities for torus observations with the Square Kilometre array and other new radio facilities

Friday
15:35

Raffaella Morganti, ASTRON/Kapteyn Institute, Groningen (NL)
morganti@astron.nl

I will give a short overview of the new radio facilities that are, or will be in the near future, available. In particular, I will concentrate on the plans for the Square Kilometre Array (SKA) and its VLBI extension. Part of the talk will be dedicated to review the possibilities that these facilities can offer for the studies of tori and their close environment, and discuss the synergy with other upcoming facilities.

Summary talk

Friday
17:05

A conference summary: is our changing look now only partially obscured?

Ric Davies, Max-Planck-Institut für extraterrestrische Physik
davies@mpe.mpg.de

I will reflect on the talks and posters presented during the meeting, to assess the current status of our understanding of the torus. Issues I will address include how our picture of the torus has developed in recent years and what questions we might answer in the near future. I will emphasize how we need to think of the torus in the context of the structures around it on both larger and smaller scales; put some focus on temporal aspects; and consider some pitfalls to avoid if we really want to unify our views.

Posters

Structure and composition

TRUE2: unveiling the nature of true Seyfert 2 candidates through optical polarimetry

Beatriz Agís González, Université de Liège & KULeuven
bagis@uliege.be

True Seyfert 2 candidates are those Seyferts galaxies whose optical spectral do not show broad lines, while in the X-ray domain they exhibit some characteristic behavior of Seyferts 1 such as lack of X-ray obscuration and/or short timescale variability. A true 2 candidate will be confirmed as a true Seyfert 2 galaxy if the lack of broad line region (BLR) emission is not only observational but physical. In total light the BLR is hidden behind the circumnuclear dust, only polar-scattered light can tell us about the presence or absence of the BLR. Hence, scattering-induced polarization is the only way to probe the existence of hidden-BLRs (HBLR). Since true Seyfert 2 candidates are selected by lack of X-ray obscuration, the most plausible explanation to cause the non-detection of a HBLR would be the absence of an efficient scattering medium. At the same time, the presence of an efficient scattering region would imply a highly polarized continuum. To answer those questions, we have obtained imaging polarimetry (much less time-consuming than spectropolarimetry) to assess what degrees of broad-band polarization are high enough to indicate the presence of a scattering medium able to act as a mirror and thus providing us with an indirect view of the HBLRs. In this contribution, we will report the analysis of a new broad-band polarimetric dataset of 10 true Seyfert 2 candidates. Comparing the measured continuum polarization with simulations we will be able to constrain the morphology, localization, density and composition of an efficient/non-efficient scattering region. We will apply STOKES, a Monte Carlo radiative transfer code which can be used to model, predict, fit and interpret the polarization of AGN. This will allow us to get insights on the true morphology of the scattering region, the BLR and optically-thick circumnuclear dusty region all at once.

GMOS-IFU observations of bi-polar ionization cones in z 0.3 QSO2s

Bruno Dall'Agnol de Oliveira, Universidade Federal do Rio Grande do Sul (UFRGS)
bruno.ddeo@gmail.com

We present results of recent GMOS-IFU observations of bi-polar ionization cones in nearby QSOs observed in excitation maps constructed as ratios of narrow-band optical images obtained with the Hubble Space Telescope (HST). We present maps of the gas kinematics and derive the extent of associated outflows as well as its mass outflow rate and power. The bi-conical geometry of the excitation maps indicates the presence of the torus even at the corresponding high AGN luminosities ($\sim 10^{45}$-10^{46} erg/s) and we use the data also to constrain the properties of the torus.

Suzaku Observations of Moderately Obscured (Compton-thin) Active Galactic Nuclei Selected by Swift/BAT Hard X-ray Survey

Taiki Kawamuro, NAOJ
taiki.kawamuro@nao.ac.jp

We report the results obtained by a systematic, broadband (0.5–150 keV) X-ray spectral analysis of moderately obscured (Compton-thin; $22 < \log N_H < 24$) active galactic nuclei (AGNs) observed with Suzaku and Swift/BAT (Kawamuro et al. 2016b). Our sample consists of 45 local AGNs at z < 0.1 with $\log L_{14-195\mathrm{keV}} > 42$ detected in the Swift/BAT 70-month survey, whose Suzaku archival data are available as of 2015 December. All spectra are uniformly fit with a baseline model composed of an absorbed cutoff power-law component, reflected emission accompanied by a narrow fluorescent iron-Kalpha line from cold matter (torus), and scattered emission. Based on the above analysis, we find that the averaged reflection strength derived from stacked spectra above 14 keV is larger in less luminous ($logL_{10-50\mathrm{keV}} <= 43.3$; $R = 1.04^{+0.17}_{-0.19}$) or highly obscured AGNs ($\log N_H > 23$; $R = 1.03^{+0.15}_{-0.17}$) than in more luminous ($\log L_{10-50\mathrm{keV}} <= 43.3$; $R = 0.46^{+0.08}_{-0.09}$) or lightly obscured objects ($\log N_H <= 23$; $R = 0.59^{+0.09}_{-0.10}$), respectively. Also, an interesting finding is that the [O IV] 25.89 um line to X-ray luminosity ratio is significantly smaller in AGNs with lower soft X-ray scattering fractions, suggesting that the [O IV] 25.89 um luminosity underestimates the intrinsic power of an AGN buried in a small opening-angle torus.

Polar Dust in AGN: The case of ESO 323-G77

James Leftley, University of Southampton
jl30g12@soton.ac.uk

Studies of local Seyfert galaxies with infrared interferometry have shown a strong extended dust emission from the polar region in most objects, with a subdominant compact or disk-like component in the plane of the accretion disk. We report on our results of ESO 323-G77, a Sy1 studied in detail with MIDI. While we also find strongly polar-elongated dust emission (axis ratio 3:1), as in other Seyfert galaxies, the polar emission only contributes about 40% to the total mid-IR emission, and thus is not dominant. The remaining flux originates from an unresolved component. Using the full IR SED and the 3D radiative transfer model CAT3D-WIND, we interpret this unresolved mid-IR emission as the Rayleigh-Jeans tail of hot dust from the inner part of a dusty disk close to sublimation. We show that, together with the compact emission seen in two quasars, this may suggest an evolution of the dust distribution with Eddington ratio. We conclude with preliminary results of 7 new AGN where we test this dependence as well as with prospects for imaging with the new mid-IR interferometer MATISSE.

The origin of the mid- and far-infrared polarization of the torus in active galaxies

Enrique Lopez-Rodriguez, SOFIA Science Center
elopezrodriguez@sofia.usra.edu

We investigate the role of magnetic fields in the unification scenario and detect the signature of a globally coherent magnetic field and a well-defined dusty structure in the radio-loud active galactic nucleus (AGN), Cygnus A. These results are based on the combination of 2-13 um imaging polarimetry using NICMOS/Hubble Space Telescope and CanariCam/Gran Telescopio CANARIAS with newly obtained 53-89 um imaging polarimetric observations using HAWC+/SOFIA. We found that the synchrotron emission is insignificant in the infrared (IR). We also found that the total and polarized fluxes show a 2-500 um IR bump peaking at ∼40 um. We concluded that the 12-100 um polarization arises from emission of aligned dust grains in a coherent dusty and magnetic structure around the active nucleus at scales of 10-20 pc. In contrast to these results, we found that the core of radio-quiet AGN are generally low polarized (<1%) in the mid-IR (MIR) at scales of ∼10s of pc, while MIR polarization up to 6% is observed over extended structures along the narrow line regions (i.e. NGC 1068 and NGC 4151) at scales >100 pc. We have learned that the MIR nuclear polarization of highly obscured objects arises from a self-absorbed MIR polarized clumpy torus and/or extinction from the host galaxy. For unabsorbed cores, MIR polarization arises from dust scattering in the torus and/or surrounding nuclear dust. These results are based on sub-arcsecond 8-13 um imaging- and spectrometric-polarimetric observations of radio-quiet AGN using CanariCam on the Gran Telescopio CANARIAS. We will present a review of the near- to far-IR (FIR) polarimetric studies of AGNs that includes these results, discusses what we have learned from the multi-wavelength polarimetric studies, and forecasts the potential of this analysis using future FIR polarimetric observations.

Stellar and dusty cusp at the heart of NGC1068

Daniel Rouan, LESIA Observatoire de Paris
daniel.rouan@obspm.fr

SPHERE-VLT near-IR images in H and Ks of NGC1068 are used to derive the radial distribution of brightness in the central r ¡ 100 pc area down to the pc scale. We find that the fit of brightness radial profiles beyond 10pc is done quite precisely in Ks by a cusp of exponent -2.0 plus a central point-source and by a cusp of exponent -1.3 in H. The difference of exponents between H and Ks is well explained by differential extinction, provided that the distribution of dust is itself cuspy, with an exponent -1.0. The actual stellar density is then found to follow a $r^{-}4$ cusp, which is much steeper than any other cusp theoretically predicted around massive black hole, or observed, either in the center of early- or late-type galaxies or in mergers at different stages. NGC1068 is however shown to satisfy a relationship between half-light radius, cusp luminosity and exponent that we find for the sample of LIRGs/ULIRGs studied by Haan (2013), This suggests strongly that the cusp is the remnant of a recent starbust. We identify the central point-like source with the very hot dust at the internal wall of the putative torus and derive a luminosity that requires an overall extinction $A_K \sim 10$, a value consistent with predictions by models and at least explained for 60% by the cuspy dust. The overall picture revealed by this study seems well consistent with the scheme of a continuously denser and denser concentration of matter when approaching the central engine, providing a natural bridge to the compact and dense structure most commonly referred to the putative torus. It also brings strong constraints on the mechanism to feed the accretion disk.

High resolution imaging of the molecular torus in NGC 1052 with VLBI

Satoko Sawada-Satoh, JSF/NAOJ
swdsth@gmail.com

High angular resolution studies of molecular gas in the center of the extragalaxies (< 1 kpc) have been obtained with millimeter interferometers. The size of the torus, however, is smaller than 10pc, and a milliarcsecond (mas) resolution is required to study its internal structure in nearby AGNs. VLBI observations have revealed the parsec- or subparsec-scale morphology of nearby AGNs. Although thermal emission lines from molecular gas are not luminous enough to detect with the VLBI, VLBI maps can display thermal absorption lines of the gas in silhouette against a bright background synchrotron radiation source with a mas resolution. We present the first VLBI detection of HCN molecular absorption in the nearby AGN NGC 1052. The absorption features are localized on the receding jet side, where the free-free absorption occurred due to the torus.

Reprocessing & Variability

Estimation of the physical parameters of the torus using a mid-IR and X-ray simultaneous spectral fitting.

Donaji Esparza Arredondo, Instituto de Radioastronomía y Astrofísica, UNAM
d.esparza@irya.unam.mx

Spectroscopic studies have been broadly used to characterize the main properties of the torus in AGN. However, the torus has a large number of parameters that have not been constrained yet. Near-to-mid infrared wavelengths have been broadly used to try to constrain these parameters thanks to the remission of dust at these wavelengths. Reprocessed X-ray emission in the inner walls of the torus (the so-called reflection component) is also a good tracer of the torus properties. We explore if the combination of X-ray and mid-infrared spectra can better constrain the physical parameters of the torus. To meet our goal we used the nearby type-1.5 NGC 3516 as a pilot target. We included the high spectral resolution IRS/Spitzer spectra for mid-infrared observations and NuSTAR observations for X-rays. We used the Clumpy models for mid-infrared spectra and the radiative transfer code Borus for X-ray spectra to fit the data. The Borus model can be fitted with the X-ray spectral fitting software XSPEC. We develop a code able to convert Clumpy models and IRS/Spitzer spectra into XSPEC format to simultaneously fit mid-infrared and X-ray data. We found that simultaneous fit, when compared to mid-infrared or X-ray spectral fit results, is able to better constrain the X-ray photon index (Γ) of the incident AGN emission, the optical depth of individual clouds (τ), the inclination angle toward the torus, the angular size of the torus (σ), and the steepness of the cloud distribution (q). These obtained values are consistent with a Type-1 Seyfert, as infer from optical analysis. Thus, we probed that this technique is one of the best methods so far to infer the physical properties of the torus using spectroscopic data.

X-Ray Spectral Model from Clumpy Torus and Its Application to Circinus Galaxy

Atsushi Tanimoto, Kyoto University
tanimoto@kusastro.kyoto-u.ac.jp

We construct an X-ray spectral model from a clumpy torus with Monte Carlo simulation for Astrophysics and Cosmology (MONACO: Odaka et al. 2016). The geometry of the torus is the same as that in Nenkova et al. 2008, who adopted a power law distribution in the radial direction and a normal distribution in the angular direction. We investigate the dependence of the X-ray continuum and Fe Ka line profile on the torus parameters. Then, we compare our model with other torus models such as MYTorus model (Murphy & Yaqoob 2009), Ikeda torus model (Ikeda et al. 2009), and CTorus model (Liu & Li 2014). We apply our model to the broadband X-ray specta of the Circinus galaxy observed with Chandra, XMM-Newton, Suzaku, and NuSTAR. We discuss the fitting results in comparison with those obtained from the infrared data.

Calibrating the BH mass-stellar-velocity dispersion relation with spatially-resolved kinematics of reverberation-mapped AGNs

Vardha N. Bennert, California Polytechnic State University
vbennert@calpoly.edu

Reverberation mapping provides the most robust black-hole mass (MBH) measurements of active galaxies (AGNs) beyond the local Universe. The relationship between MBH and stellar-velocity dispersion (sigma) is considered to be the tightest of the observed MBH-host-galaxy scaling relations. It has been used traditionally to determine the multiplicative offset "f" needed to match the MBH-sigma relation of AGNs to that of quiescent galaxies. Some studies suggest differences between the slopes of the relation of AGNs and quiescent galaxies, but the small range in MBH of RM AGNs studied so far has limited the accuracy to which the slope can be determined. Moreover, in a recent study, we showed that sigma can vary on average by up to 40% across definitions common in the literature. 3D spectroscopy is the only way forward for a precise measurement of sigma. We present first results of a program that targets massive AGNs of our recent LAMP2016 reverberation-mapping campaign using KCWI. When combined with literature data and a sample observed with VLT/MUSE, we more than double existing data in the high mass regime, essential to determine the slope of the MBH-sigma relation, its intercept and scatter, constrain the average f factor, and identify dependencies of the relation on luminosity, Eddington ratio and host-galaxy morphology. Our sample forms the crucial low-z anchor for the determination of MBH in AGNs throughout the Universe.

Optically variable active galactic nuclei in the 3 yr VST survey of the COSMOS field

Demetra De Cicco, Instituto Milenio de Astrofísica - Pontificia Universidad Católica de Chile
demetradecicco@gmail.com

Variability characterizes AGNs at all wavelengths, with timescales from minutes to years depending on the observing window. Variability measurements can contribute in shedding light on the underlying emission mechanism, providing constraints on the size and structure of the emitting region. The analysis of AGN variability at different wavelengths and the study of possible correlations among different spectral windows is nowadays a major field of inquiry. Optical variability has been extensively used to identify unobscured AGNs in multi-epoch surveys. The strength of a selection method based on optical variability lies in the chance to analyze data from surveys of large sky areas by ground-based telescopes. Plus, variability allows to retrieve those AGNs characterized by low X-ray emission and hence not classified as AGNs on the basis of their X-ray properties; also, it proves effective in unearthing low-luminosity AGNs because of the anti-correlation between AGN luminosity and variability amplitude. We tested the use of optical variability as a tool to identify AGNs in the VST multi-epoch survey of the COSMOS field, originally tailored to detect supernova events. We pushed towards deeper magnitudes than in past studies and made wide use of ancillary multi-wavelength catalogs in order to confirm the nature of our AGN candidates and constrain the accuracy of the method based on spectroscopic and photometric diagnostics. The effectiveness of our selection technique against other traditional photometric approaches was already explored in De Cicco+ 2015. Here we confirm that the method allows the selection of high-purity (>80%) samples, and we take advantage of the long observing baseline to achieve great improvement in the completeness of our sample: the extension of the analysis from a five-month to a three-year baseline

led to a significant increase in the completeness of the AGN selection with respect to optical/IR/X-ray confirmed samples of AGNs, rising from 15% up to ∼50%, with a strong dependence on the source apparent magnitude. The reliability of our selection technique is of great relevance in the framework of current and planned multi-epoch wide-field surveys (e.g., LSST), which will use variability as one of the main AGN discovery approaches, combining it with complementary selection methods. We also present our results from the investigation of the dependence of AGN variability on black hole mass and accretion rate, performed by computing the structure function of the X-ray confirmed AGNs in our sample. Our results support the existence of an anti-correlation with the accretion rate, while no relation with the black hole mass emerges, consistently with other works from the literature.

Mapping the X-ray outflow in local AGN

Tracey Jane Turner, UMBC
tjturner@umbc.edu

The emerging picture for the X-ray reprocessor is one comprising several zones of outflowing clouds whose number density falls off from the plane to the pole of the accretion disk, providing an inclination dependence to the observed X-ray properties. X-ray observations are especially valuable because they appear to trace a large radial extent for the reprocessing gas. I summarize results from recent work and highlight new constraints from an XMM/NuSTAR campaign on NGC 3227.

Dust reverberation mapping in the ESO Public Survey VEILS

Ella Guise, University of Southampton
ellaguise@gmail.com

We report initial science results from the ESO Public Survey VEILS, with the aim of performing dust reverberation mapping on 500 AGN out to redshift z=1.2.

Mapping the torus with NIR and optical variability

Rosamaria Carraro, Universidad de Valparaíso
carrarorosamaria@gmail.com

Standard candles are a very important instrument in Astronomy to obtain redshift independent measures of distance in order to constrain cosmological models. We investigate a method (presented in e.g. Hoenig 2015) to use AGN as standard candles using the disk-torus correlation. We use 3-year long light curves from 10 known AGN at z¡0.5 in a 3 orders of magnitude luminosity range in order to estimate the time-delay between optical and NIR flux variations, thereby tracing the variation of disk and torus respectively. We assume a constant sublimation temperature and we obtain the relative amplitude of variation to compare to already known and studied disk-torus systems. This gives us the distance of the disk to the torus and therefore the luminosity of the AGN by assuming a constant dust sublimation temperature. We further compare his distance to other distance estimates of these galaxies in order to study the reliability of the dust reverberation distance estimation method in a range of AGN of different luminosities. This study will be extremely useful when new monitoring wide sky surveys become available, such as SDSS5 and LSST to apply on large samples of AGN in conjunction with wide field IR monitoring.

Torus in its surrounding

What causes the ILR emission in AGN?

Tek Prasad Adhikari, Nicolaus Copernicus Astronomical Center of the Polish Academy of Sciences

tek@camk.edu.pl

The intermediate-line component required to fit the recently observed emission spectra of several AGN points to the possible existence of a physically separate region between the BLR and the NLR. In this work, we use the CLOUDY photoionization simulations of the gas clouds distributed radially from the AGN center with typical distances for the BLR, ILR, and NLR. The appearance of dust at the sublimation radius is fully taken into account. We consider different density profiles to define the radial distribution of the gas clouds and computed the resulting line emissivities for major emission lines as a function ofthe radial distance. We show that the observed component of ILR can be successfully explained if we consider the high value of gas density i.e., $\geq 10^{11.5}$ cm^{-3} in the emitting region. We found that the low-ionization line, Fe II, appears to be highly sensitive to the presence of dust and therefore becomes a potential tracer of dust content in line-emitting regions. We show that the use of the density profile expected in the upper part of the accretion disk atmosphere reproduces the observed properties of the line emissivities. In particular, the distance of the Hβ line inferred from our model agrees well with the the result obtained from the reverberation mapping studies in the Sy1 galaxy NGC 5548.

What causes the ILR emission in AGN?

Diagnostic Diagrams for galactic nuclei: an alternative approach

catarina.aydar@gmail.com

Diagnostic Diagrams, inspired in the original BPT diagrams (Baldwin, Phillips and Terlevich, 1981) have been proposed using emission line ratios such as [OIII]/Hβ, [NII]/Hα, [SII]/Hα and [O I]/Hα. Such schemes have been widely used in the literature. We analyze a large sample of galactic nuclei from the Palomar sample (Ho et al 1997) and propose additional diagrams using different combinations of line properties. These additional diagrams are interpreted with the use of CLOUDY simulations.

Gemini IFU observations of the OH Megamaser Galaxy IRAS 11506-3851

Claudia Cassanta, Universidade Federal de Santa Maria - UFSM
claudinha1258@gmail.com

The OH Megamaser (OHMs) are powerful extragalactic masers which emit predominantly at microwave frequencies, in 1665 and 1667 mega-hertz (MHz). Generally, OHMs have been observed in Luminous Infrared Galaxies (LIRGs), a class of galaxies among the most luminous objects in the universe showing infrared (IR) luminosities above 10^{11} Lsun. These objects consist typically of a mixture of galaxy pairs, galaxy interactions, and/or galaxy mergers. We have obtained observations of the OH megamaser galaxy IRAS 11506-3851 using Gemini Multi-Object Spectrograph (GMOS) Integral Field Unit (IFU). IRAS 11506-3851 has a redshift z = 0.010781 and it is at a distance of 48 Mpc. This galaxy is part of a sample of 15 OH megamaser galaxies from a project that has the overall goal of relating the OH maser properties to Active Galactic Nuclei (AGN) and Starburst (SB) activity in order to understand the mechanism of ionization of the galaxies with OHMs. The GMOS-IFU data cover the spectral range of 4800 to 7500 Å. Preliminary results show that the emission-line flux distributions present extended emission along all the field of view and suggest the presence of a ring of circumnuclear star forming regions located between 1."5 and 2."6 from the nucleus. In addiction, the diagnostic diagrams suggest evidence that the galaxy is a SB with an AGN immersed in dust and gas.

SOFIA/FORCAST Resolves 30 - 40 micron Extended Dust Emission in Nearby Active Galactic Nuclei

Lindsay Fuller, University of Texas at San Antonio
lindsay.fuller@utsa.edu

We present arcsecond-scale observations of seven nearby Seyfert galaxies observed from the Stratospheric Observatory For Infrared Astronomy (SOFIA) using the 31.5 and 37.1 micron filters of the Faint Object infraRed CAmera for the SOFIA Telescope (FORCAST). We isolate unresolved emission from the torus and find extended diffuse emission in six 37.1 micron residual images in our sample. Using Spitzer/IRS spectra, we determine the dominant mid-infrared (MIR) extended emission source and attribute it to dust in the narrow line region (NLR) or star formation. We compare the optical NLR and radio jet axes to the extended 37.1 micron emission and find coincident axes for three sources. For those AGN with extended emission coincident with the optical axis, we find that spatial scales of the residual images are consistent with 0.1 - 1 kpc scale distances to which dust can be heated by the AGN. Using previously published subarcsecond resolution 1 - 20 micron imaging and spectroscopic data along with our new observations, we construct broadband spectral energy distributions (SEDs) of the AGN at wavelengths 1 - 40 micron. We find that three AGN in our sample tentatively show a turnover in the SED between 30 - 40 micron. Using results from Clumpy torus models and the Bayesian inference tool BayesClumpy, we find that the posterior outputs for these AGN show narrower posterior distributions.

Radio continuum of active galaxies with water megamaser disks

Fateme Kamali, Max-Planck Institute for Radio Astronomy
fkamali@mpifr.de

Investigating the alignment between the radio jet and the rotation axes of the sub-pc sized accretion disks is one of the main paradigms of models describing active galactic nuclei (AGNs). Due to the small linear and angular scales involved, this paradigm has not yet been checked in a sufficient number of Low Luminosity Active Galactic Nuclei (LLAGNs). In order to probe this paradigm we observed a sample of LLAGNs using the Very Large Array (VLA), Very Large Baseline Array (VLBA) and the Multi-Element Radio Linked Interferometer Network (MERLIN) at 33GHz, 5GHz and 5GHz respectively. All galaxies in our sample exhibited an edge-on accretion disk obtained from 22GHz H2O megamaser emission. Our observations suggest that as we go to higher resolution the number of detected sources decreases, possibly due to resolving out the extended emission. Little evidence is present for extended radio jets on scales greater than 3 kpc. For 50% of galaxies in our sample, which exhibit known megamaser disk's orientation, the pc-sized radio continuum is perpendicular to the sub-pc scale accretion disk (water megamaser disk). We show that the radio continuum luminosities are strongly correlated with the maser disk's inner and outer radii, suggesting a possible connection between the two properties.

The dust and cloud distribution of the torus of NGC 1068

Enrique Lopez-Rodriguez, SOFIA Science Center
elopezrodriguez@sofia.usra.edu

The 8-13 microns (mid-IR) spectral range has proven to be exceptionally rich in spectral features that can be used to characterize the dust emission properties of AGN. At longer wavelengths (> 20 microns), the moderate angular resolution (>10 arcsec) observations available by space-based telescopes have made the characterization of nearby AGN very challenging. This is because of the large contribution of the host galaxy at longer wavelengths and the difficulties to isolate the AGN emission from other components within these moderate angular resolution observations. From the ground, IR observations at wavelengths > 20 microns are impossible due to the atmosphere. Thus, the cold dust of the torus is poorly constrained as well as the turn-over of the torus emission. The Stratospheric Observatory For Infrared Astronomy (SOFIA) has opened a new window to explore AGN in the range of 20-300 microns with angular resolution < 10arcsec. We here present newly 20-53 um imaging observations using FORCAST and HAWC+ onboard SOFIA of NGC 1068 that, in conjunction with high-angular resolution 1-13 um and sub-mm observations, allow us to characterize the obscuring torus. Using CLUMPY torus models, we inferred the best torus model parameters and we computed 2D images of the dust emission and cloud distribution at several wavelengths from 2 to 432 um. We found that 1) the 1-20 um wavelength range solely is not able to probe the full extend of the torus; 2) the turn-over of the torus emission occurs in the 30-40 um which is sensitive to the detection of cold dust in the torus, and 3) the morphology of the dust emission in our 2D image at 432 um is spatially coincident with the cloud distribution of the torus using 432 um ALMA observations. We also found that the dust emission from our 2D clumpy torus image at 12 um shows an elongated morphology perpendicular to the cloud distribution, and can produce comparable results to those observed using IR interferometry.

Dynamics

The molecular and ionized gas kinematics in a sample of Seyfert galaxies

Marina Bianchin, Universidade Federal de Santa Maria - UFSM
marinabianchin17@gmail.com

The understanding of feeding and feedback process in active galatic nuclei (AGN) is fundamental to constrain the evolution scenario of galaxies. In the present work we study the gas kinematics of six hosting AGNs galaxies: Mrk607, NGC788, NGC3227, NGC3516, NGC5506 and NGC5899. These objects were observed with the NIFS (Near-infrared Integral Field Spectrograph) spectrograph (Gemini North Telescope) in the J and K bands. The NIFS FoV is of 3"x3" with a spatial resolution of ∼0.15". These galaxies belong to a sample selected by our group which main selection criteria are: (i) luminosity LX $\geq$ 1041.5 ergs s-1 in the Swift-BAT 60-month 14-195 keV band, (ii) redshift z $\leq$0.015 and (iii) being observable by the NIFS (-30 $< \delta <$ 73). We used the routine PROFIT (line-PROfile FITting) to fit the emission line profiles of [P II]λ1.1886μm, [Fe II]λ1.2570μm, Pa$\beta\lambda$1.2822μm, H2λ2.1218μm e Br$\gamma\lambda$2.1661μm by Gauss-Hermite series. As a result from the fitting we obtain flux, line-of-sight velocity, velocity dispersion and Gauss-Hermite moments h3 and h4 for each emission line. In the six galaxies a rotation pattern is observed for the molecular gas with low velocity dispersion values (¡100 km/s). The ionized gas, in general, does not follow the rotation pattern and is possibly associated with outflows from the AGN. A detailed analysis of gas kinematics is being performed thourgh the the fitting of rotation models to the observed velocity fields and the interpretation of the residuals maps, such procedure will allow the identification and quantification of gas inflows and outflows from the AGN.

A close look at the dwarf AGN of NGC4395: optical and near-IR integral field spectroscopy

Carine Brum, Universidade Federal de Santa Maria
carinefisica@gmail.com

Intermediate mass black holes (10^3-10^5 Msolar) in the center of dwarf galaxies are believed to be analogous of growing Active Galactic Nuclei (AGN) in the early Universe. Their characterization can provide insight about the early galaxies. We present optical and near-infrared integral field spectroscopy of the inner ∼50pc of the dwarf galaxy NGC4395, known to harbor an AGN. NGC4395 in an ideal candidate to investigate the nature of dwarf AGN, as it is nearby enough to allow close look of its nucleus. The optical data were obtained with the Gemini GMOS-IFU and cover the 4500 to 7300 angstrom spectral range at a spatial resolution of 10 pc. The J and K-band spectra were obtained with the Gemini NIFS at spatial resolutions of ∼5pc. The emission-line flux distributions reveal an elongated structure at 24 pc west of the nucleus, which is blueshifted relative to the systemic velocity of the galaxy by ∼30km/s. This structure is interpreted as being a gas-rich minor merger inflowing towards the nucleus. In addition, the gas kinematics shows a compact rotation disk component with a projected velocity amplitude of 25km/s. We estimate a mass of 7.7x10^5 Msolar inside a radius of 10 pc. From the Halpha broad line component, we estimate the AGN bolometric luminosity as $Lbol = 9.9 \pm 1.4) \times 10^{40}$ erg/s and a mass $_{\rm BH} = 2.5^{+1.0}_{-0.8} \times 10^5$ Msolar for the central black hole. The mean surface mass density for the ionized and molecular gas are in the ranges (1–2) Msolar pc^{-2} and (1-4)x10^{-3} Msolar pc^{-2} and the average ratio between ionized

and hot molecular gas masses is ∼500. We found that the gas reservoir available to feed the central AGN of NGC4395 is smaller than that seen in typical Seyfert galaxies, but it is at least 3 orders of magnitude larger than the mass needed to fuel the AGN. While gas inflows are seen along nuclear dust spirals and bars for typical Seyfert, for NGC4395 the inflows seem to be associated to a minor merger.

Dissecting OH Megamaser Galaxies: the case of IRAS23199+0123 and IRAS03056+2034

Hekatelyne Carpes, Universidade Federal de Santa Maria

hekatelyne.carpes@gmail.com

(Ultra)luminous infrared galaxies ([U]LIRGs) present infrared (IR) luminosities of Lir ¿10^{12} Lsun and are probably the result of galaxy interactions and mergers. These merging systems are commonly associated with OH Megamaser galaxies (OHMs), but the environment that produces this phenomenon is still not completely understood. The OHM hosts could present features for both AGN and Starburst activity that could provide the pumping that originates the maser emission. In order to investigate the main gas excitation mechanism of OH Megamaser galaxies we have obtained multifacility observations of IRAS23199+0123 and IRAS03056+2034 with Gemini IFU, VLA and HST. The multi-wavelength study of IRASF23199+0123 allowed us to show for the first time that this object is actually an interacting pair of galaxies and detect two OH maser sources associated with the eastern member. In addition, we discovered a Seyfert 1 nucleus in IRASF23199E, via the detection of an unresolved broad double-peaked component in the Hα emission line from the BLR. The two masing sources are detected in this galaxy that hosts also an AGN, and are observed in the vicinity of enhanced velocity dispersion and higher line ratios, suggesting the association with shocks driven by AGN outflows. The HST images of IRAS03056+2034 reveal flocculent spiral arms and in combination with GMOS-IFU flux distributions indicate a ring of circumnuclear star formation. Besides, the emission-line ratios indicate the presence of both AGN and Starburst activity. The gas kinematics indicates a rotation pattern and an excess of redshifts that were associated with a patchy nuclear spiral arm seen in the HST image and was interpreted as inflows towards the nucleus.

The first 62 AGN observed with SDSS-IV MaNGA – III: stellar and gas kinematics

Gabriele Ilha, Universidade Federal de Santa Maria
gabrieleilha1994@gmail.com

We investigate the effects of Active Galactic Nuclei (AGN) on the gas kinematics of their host galaxies, using MaNGA data for a sample of 62 AGN hosts and 109 control galaxies (inactive galaxies). We compare the gas and stellar velocity fields for the two samples and do not find any difference in the Position Angle (PA) offsets between the line of nodes of gas and stars for AGN hosts and control galaxies. However, we note that AGN have larger fractional velocity dispersion σ differences between gas and stars [$\sigma_{\rm frac} = (\sigma_{\rm gas} - \sigma_{\rm stars})/\sigma_{\rm stars}$] when compared to their controls, as obtained from the velocity dispersion values of the central (nuclear) pixel (2.5" diameter). The AGN have a median value of σfrac of$< \sigma_{\rm frac} >_{\rm AGN} = 0.04$, while the the median value for the control galaxies is $< \sigma_{\rm frac} >_{\rm CTR} = -0.23$. 75% of the AGN show $\sigma_{\rm frac} > -0.13$, while 75% of the normal galaxies show $\sigma_{\rm frac} < -0.04$, thus we suggest that the parameter $\sigma_{\rm frac}$ can be used as an indicative of AGN activity. We find a correlation between the [OIII]λ5007 luminosity and σfrac for our sample. Our main conclusion is that the AGN already observed with MaNGA are not powerful enough to produce important outflows at galactic scales, but at 1-2 kpc scales, AGN feedback signatures are always present on their host galaxies.

Optical and infrared radiation pressure on dust and gas around AGN as drivers of dusty winds

Marta Venanzi, University of Southampton
marta.venanzi@gmail.com

Parsec-scale polar emission signatures seen in the infrared continuum of many nearby AGN suggest the presence of dust in a region generally associated with outflowing gas. This makes clear that the idea of a circum-nuclear obscurer referred as torus needs to be revised in favour of a more complex obscuring structure, yielding a polar component. We present a semi analytical model to test the hypothesis of radiatively accelerated dusty winds launched by the AGN and the heated dust itself. The main components of the model under consideration are an AGN and an infrared radiating dusty disk, the latter being the primary mass reservoir for the outflow. We derive the full components of the force field experienced by dusty clouds in this environment, accounting for both gravity and the AGN radiation as well as the re-radiation by the hot dusty gas clouds themselves. We see that dusty outflows naturally emerge, whose strength and directions will depend on the Eddington ratio and the column density of the intervening material.

Evolution & Parameter Space

The BH-host coevolution in local hard X-ray selected type 2 AGN

Federica Ricci, Pontificia Universidad Católica de Chile
fricci@astro.puc.cl

A pivotal role is attributed to active galactic nuclei (AGN) in the evolution of galaxies due to tight empirical black hole (BH) - host scaling relations, indicative of coevolution. However, our view is hampered by biases against the bulk of the AGN population, the optically obscured type 2 AGN, since state-of-the-art methods to directly measure the BH mass are based on optical broad lines. Indeed, due to the difficulties in measuring their BH masses, it is still unknown whether type 2 AGN follow the same BH–host galaxy scaling relations valid for quiescent galaxies and type 1 AGN, as expected in orientation-based unified models. Using NIR spectroscopy we derive virial BH masses for a sample of local hard X-ray selected type 2 AGN and pinpoint their locus in the BH-σ and BH-L_{bulge} planes, which is significantly displaced with respect to that observed in local massive galaxies. Our results pose interesting questions for the standard picture of AGN unification.

The DIVING3D project: analysis of the nuclear region of Early-type Galaxies.

Tiago Ricci, UFFS - campus Cerro Largo - Brazil
tiago.ricci@uffs.edu.br

The use of statistically complete samples is very useful in the study of the main AGN properties. In the local Universe, the Palomar Survey (PS) revealed that there is a predominance of low luminosity AGNs (e.g. Seyferts and LINERs). When it comes to nearby early-type galaxies (ETGs), almost half of these objects have some sort of nuclear activity, most of them being classified as LINERs. I will present the first results on the nuclei of all 56 ETGs that are part of the DIVING3D project, whose goal is to analyse the central region of a statistically complete sample of all galaxies of the southern hemisphere with $B < 12.0$ mag and $|b| > 100$ using seeing-limited IFU spectroscopy data obtained with the Gemini-South Telescope. Emission lines are seen in the nucleus of 88% (60% - PS) of the sample ETGs. LINERs plus Seyferts galaxies were detected in 53% (52% - PS) of the objects. A broad Hα feature is present in 27% (15% - PS) of the ETG nuclei. Transition Objects (composite spectra of a LINER and an H II region) are seen in 3% of the objects from the DIVING3D project, while in the PS they account for 9% of the ETGs. This updated information about the nuclear region of ETGs in the local Universe is a direct consequence of the higher spatial resolution of the DIVING3D data when compared to the Palomar Survey.

The existence of the dusty torus in NGC 3718

Yaherlyn Diaz, Universidad de Valparaiso
yaherlyn.diaz@postgrado.uv.cl

In understanding the place of LINERs within AGN unified schemes, a question of importance is whether LINERs have an obscuring dusty torus. Theoretically, models predict that below a certain Eddington rate the dusty torus and broad line region disappear. The X-ray spectrum is a useful tool to study the properties of the obscuring material in AGNs. There are many prominent features seen in the X-ray spectra of AGNs, one of the most important is the reflection component, produced by Compton scattering of the primary emission in material close to the X-ray source resulting in a broad hump-like shape, peaking at approx. 30 keV, in addition to the fluorescent line emission. The shape of the reflection component can help to distinguish between models of the ionized reflection from the inner accretion disk or neutral reflection from the dusty torus. The measurement of the reflector is a difficult task because it depends on the intrinsic absorption (observed at soft energies), the uncertain intrinsic spectral slope of the power-law, and its cut-off. In this work, we study the proprietary X-ray spectra of the LLAGN NGC3718. We combine observations from the most sensitive X-ray observatories in overlapping energy bands (XMM-Newton and NuSTAR) to model the spectra of this galaxy to disentangle whether the reflection can be explained by the presence of a torus or if it is due to the accretion disk, which would be in agreement with the disappearance of the torus.

ALMA Reveals the Dynamics of Hot Dust-Obscured Galaxies and the Most Luminous Galaxy Known

Tanio Diaz Santos, Universidad Diego Portales
tanio.diaz@mail.udp.cl

I will present the preliminary results of an ALMA survey of the [CII] emission line at 158um in a sample of 7 Hot Dust-Obscured Galaxies (Hot DOGs) at redshifts ∼3 to 4.6. Hot DOGs are thought to be at a key stage of their evolution, when most of the light produced by their central hyper-luminous super-massive black hole is reprocessed by a surrounding dusty structure. The ALMA data reveal a diversity of morphologies and complex kinematics, likely reflecting the disturbed dynamical state of these systems. ALMA has also provided us with a closer look to the environment of WISE 2246-0526, the most luminous galaxy known, where very recent deep observations of its far-infrared continuum emission have revealed the existence of multiple galaxy companions and resolved dusty filamentary streamers connecting the neighbor galaxies to WISE 2246-0526.

Extremely Heavily Obscured Quasars in Reddened Host Galaxies

Wei Yan, Dartmouth College
wei.yan.gr@dartmouth.edu

Few heavily obscured luminous quasars with intrinsic column densities over 10^{24} cm^{-}2 have been confirmed, while the CT fraction for more luminous quasars has important implications for their contribution to the CXB and torus parameter space. I will discuss NuSTAR observations of four WISE-selected heavily obscured quasars for which we have optical spectroscopy from the SALT and Keck Observatory. Three of the four objects are undetected with NuSTAR at 3-24 keV, while the fourth has a marginal detection; the weak observed X-rays but very high IR luminosities indicate hydrogen column densities (NH) that are at or greater than 10^{25}cm^{-2}. Using these observations to interpret our full parent sample of obscured quasars, we predicts a NH distribution with more CT and heavily-obscured AGNs. From the optical Balmer decrements obtained from Keck spectra, we found that our three extreme obscured targets lie in highly reddened host environments. This galactic extinction is not adequate to explain the more obscured AGN, but it may imply different scales of obscuration with the torus and the host galaxy.

Demystifying the Diverse IR Continuum SED Shapes among Type-1 AGNs

Jianwei Lyu, Steward Observatory, University of Arizona
jianwei@email.arizona.edu

In the classical unification scheme, type-1 (broad-line) AGNs are depicted as unobscured accreting supermassive black holes with similar face-on viewings of the circumnuclear optically thick tori. However, the dust SEDs of these systems can have significant variations, as seen among, e.g., the hot-dust-obscured galaxies, extremely red quasars, and hot-dust-free quasars, that cannot be easily explained in a uniform picture. In this talk, I will introduce a semi-empirical framework that has successfully reconciled the IR SEDs of type-1 AGNs seen at z$\sim$0 to z$\sim$6. The IR broad-band SEDs of most type-1 AGNs, regardless of luminosity or redshift, can be reproduced by a small set of templates for the accretion disk and torus, supplemented by an extended polar dust component with similar properties. There is no strong evidence for high-z type-1 AGNs with peculiar SED features compared with the low-z. The success of our simple approach provides useful insights on the dust environment of the accreting supermassive black holes and could be used as a powerful tool for many other studies, like AGN-galaxy SED decompositions and looking for candidate AGNs with polar dust emission.

Obscuration, unification and the cosmic X-Ray background

Roland Walter, Université de Geneve
roland.walter@unige.ch

The CXB spectrum differs from the integration of the spectra of individual AGN, calling for a large population, undetected so far, of strongly obscured Compton thick AGN. Such objects are predicted by unified models, which attribute most of the AGN diversity to their inclination on the line of sight, and play an important role for the understanding of the growth of black holes in the early Universe. The fraction of obscured AGN at low redshift can be derived from the observed CXB spectrum assuming AGN spectral templates and luminosity functions. We show that high signal-to-noise average hard X-ray spectra, derived from more than a billion seconds of effective exposure time with Swift/BAT and NuStar, imply that mildly obscured Compton thin AGN feature a strong reflection and contribute massively to the CXB. A population of Compton thick AGN larger than that effectively detected is not required, as no more than 6% of the CXB flux can be attributed to them. The stronger reflection observed in mildly obscured AGN suggests that the covering fraction of the gas and dust surrounding their central engines is a key factor in shaping their appearance. NuStar observations of AGNs in addition indicate clearly that reflection is correlated to the spectral slope in unobscured sources, these are the objects were soft lags are observed and where reflection is dominated by disk reprocessing. Instead obscured objects ($> 10^{22} cm^{-2}$) feature a correlation between reflection and column density characteristics of a clumpy reprocessing region located far away.