Exploring the dusty nuclear environments of nearby AGN with JWST/MIRI

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The torus and immediate surroundings

**ALMA 432μm view (0.04-0.06” res) of central 2” of NGC1068**
- Torus of dust and molecular gas (7-10pc)
- Circum-nuclear disk (300pc x 200pc) with on-going/recent SF activity

- Torus dust emission peaks in MIR
- Angular res of JWST/MIRI IFU (0.3”-0.5”, similar to MIR instruments on 10m class telescopes) of AGN cannot fully resolve these structures!

For reference at D=50Mpc, 0.3”=70pc

García-Burillo+2016
Open questions about the nuclear regions of AGN

- Unification of AGN: Does ONE torus explain it all?
- Implications for z evolution of type I/type II AGN

- Low luminosity AGN and the origin of the torus
- Nuclear SF and connection with torus/AGN properties
- Role of inflows/outflows in feeding the AGN and quenching/triggering SF
- Implications for BH growth and connection to galaxy evolution

- Properties of dust in the nuclear regions of AGN and surrounding host galaxy

Talk by Daniel Asmus
Infrared emission from clumpy dusty torus

Modelling of unresolved IR emission of AGN allows to derive:
- geometric properties of the torus: angular size, physical size
- distribution of clouds, optical depth, number of clouds
- AGN viewing angle and bolometric luminosity

NIR hot dust
MIR warm dust
FIR cool dust

and review Hönig (2013)
Examples of fits to unresolved IR emission

- **Arp299-B1**
  - Ground-based range 7-13μm
  - CC spectrum

- **NGC2992**
  - CC spectrum

- **UGC5101**
  - Type 1
  - Type 2

References:
- AAH+2011, 2013; Martínez-Paredes, AAH+2015; García-Bernete+2015
Geometrical covering factors of local AGN

AAH+2011, 2013; Ramos Almeida+2011; Martínez-Paredes, AAH+2015; Mori+2015

Modelling of unresolved IR 1-28μm emission with JWST will allow to derive torus properties covering:

- range of $L_{bol}$: LLAGN to QSO (receding torus, disappearance of torus)
- different z's
Seyferts show rotating nuclear thick H$_2$ disks ($d\sim 60\text{pc}$) with enhanced H$_2$ emission compared to non-AGN feeding AGN, SF?

However, H$_2$ at 2.12$\mu$m traces warm ($T\sim 1000\text{K}$) gas and only a small fraction of total molecular gas mass.

MIRI will observe mid-IR H$_2$ transitions which probe the bulk of the molecular gas + comparison with ALMA estimates.
Using the 11.3µm PAH feature to probe nuclear SF

GTC/CanariCam data at 0.3” resolution

PAH molecules are not destroyed in nuclear regions of AGN

Ramos Almeida+2014; AAH+2014
SFR vs. black hole accretion rate

Diamond-Stanic & Rieke 2012

Circumnuclear (r=1kpc) SFR from Spitzer 11.3µm PAH and 24µm

Nuclear (r=50-200pc) SFR from ground-based 11.3µm PAH
SF in nuclear regions of AGN

Diamond-Stanic & Rieke 2012

- [NeII] 12.8 µm contaminated by AGN emission

- Nuclear PAH emission might be excited by AGN
  (talk by Jens Jensen)

Esquej, AAH+2014

NIRSpec + MIRI IFU observations will allow to study AGN/SF excitation of nuclear PAH emission and obtain accurate SFR using a variety of indicators: recombination lines, fine structure lines, stellar populations
Inflows/Outflows in AGN

Müller-Sánchez+2009

Outflows detected in CO(3-2) with ALMA

García-Burillo+2014

Inflows detected in H$_2$ at 2.12$\mu$m with VLT/SINFONI

NGC 1068

AGN inflows and outflows are largely unexplored in mid-IR: H$_2$ lines, fine structure lines
Summary

NIRSpec+MIRI IFU (+ALMA) observations of central regions of local AGN will provide an exquisite view into the relation between BH growth and star formation in galaxies.

- **Outflows:** NIRSpec + MIRI (emission lines)
  - Molecular gas reservoir: MIRI (H$_2$ lines)
- **Inflows:** NIRSpec + MIRI (H$_2$ lines)
- **Obscuring Material:** MIRI (dust emission)
- **SF:** NIRSpec + MIRI (PAHs, emission lines, stellar pops)