A Compilation of Active Galactic Nuclei in the MOONRISE Fields

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Introduction & Motivation

This work aims to produce the most complete multiwavelength catalogue of active galactic nuclei (AGN). The catalogue will cover 3 sky regions:

- Wide Chandra Deep Field-South (W-CDF-S),
- XMM-Large Scale Structure (XMM-LSS),
- Cosmic Evolution Survey (COSMOS).

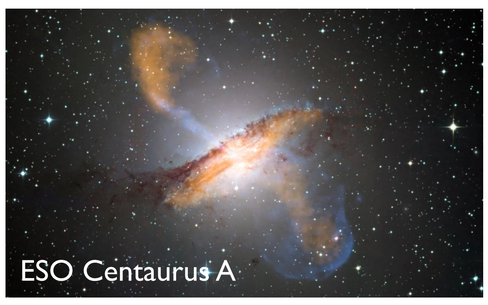
These fields have been observed by existing surveys (e.g. [1]) with AGN being selected and identified (in e.g. [2],[3]) but a compiled multiwavelength AGN catalogue does not exist.

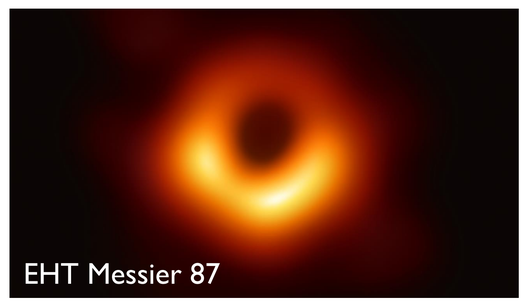
The purposes of creating this AGN catalogue are:

- To study AGN and the effects on their host galaxies,
- To produce a comprehensive selection of AGN for observation with the upcoming Multi-Object Optical and Near-infrared Spectrograph (MOONS).

Why Active Galactic Nuclei?

AGN are thought to come from accretion onto a supermassive black hole (SMBH). They emit over the full electromagnetic spectrum. AGN have broader spectral energy distributions (SEDs) than those from only dust and stars. It is observed that the masses of AGN are correlated with the masses of their host galaxies (e.g. [4]). Feedback from AGN is also thought to play a role in the star formation history of galaxies. These suggest AGN play a significant role in galaxy evolution.

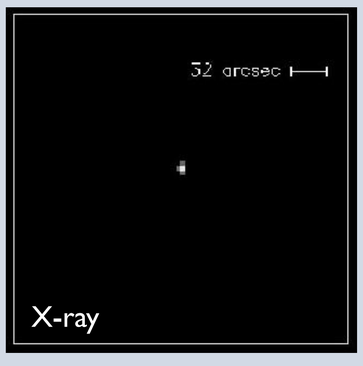




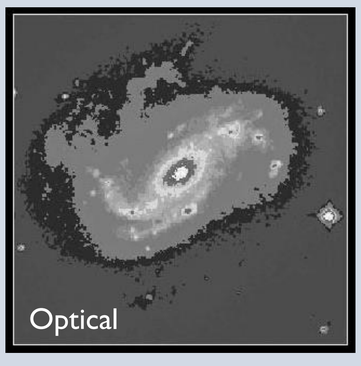
Identifying Active Galactic Nuclei

X-ray selection:

- Unlink star-forming (SF) galaxies, AGN can emit strongly in the X-rays.
- X-ray emission is not affected by starlight or obstructing dust and so is effective at selecting AGN.
- The figures show the same galaxy at X-ray and optical wavelengths demonstrating X-rays can separate AGN from star-formation.



Seyfert galaxy NGC4051 observed with ROSAT (left) and SDSS (right) [5]



Infrared selection:

- The dusty torus surrounding an AGN emits infrared (IR) radiation.
- AGN and star-forming (SF) galaxies are distinct in the IR region of SEDs.
- Several IR criteria can separate AGN from SF galaxies:
  - e.g. those of Lacy et al , Stern et al, Donley et al [7],[8],[9]
- These criteria can be contaminated by high-redshift non-AGN galaxies [10].

SED selection

- The spectral energy distributions (SEDs) of AGN tend to be much broader than those of SF galaxies and can often be described as a power law.
- SED fitting programs such as CIGALE [6] can compare AGN and non-AGN templates when fitting making SEDs a possible selection technique.

Optical selection:

- AGN appear as point sources at optical wavelengths.
- Many have bluer optical colours than star-forming galaxies.

Radio selection:

- AGN can produce very high radio luminosities that are incompatible with star formation processes.

Ongoing and Planned Work

Summary

- We are producing the most complete multiwavelength catalogue of active galactic nuclei (AGN) in three sky regions
- This catalogue will be used as:
  - A guide for AGN to observe with MOONS,
  - A compilation to study AGN and their role and interaction with their hosts.

Ongoing and Planned Work

- Radio selected AGN will be added to improve/increase catalogue completion.
- SEDs will be fit using CIGALE [6] to calculate important properties of selected AGN such as stellar masses, star formation rates, ages and AGN contribution.
- The final AGN compilation will be observed with MOONS adding to and improving the available data.
- Additional IR criteria (KI, KIM) [10]

MOONS & MOONRISE

Multi-Object Optical and Near Infrared Spectrograph (MOONS)

- State-of-the-art instrument to be fitted to the Very Large Telescope in Chile.
- International project co-led by Portugal. Key components of the instrument were designed by a team at the Instituto de Astrofísica e Ciências do Espaço.
- One of the main goals is to trace galaxy evolution.
- Improves upon optical surveys by using near infrared to observe more distant galaxies at the peak of galaxy activity in the Universe ($z > 2$)

MOONRISE

- MOONS extragalactic GTO survey.
- Observe key properties of up to half a million intermediate redshift galaxies and a few thousand galaxies at the epoch of reionisation.
- Will revolutionise out knowledge of galaxy formation.

References: 1. Weaver et al. 2022, 2. Whittam et al 2022, 3. Zou et al 2022, 3. Reines & Volonteri 2015, 5. https://ned.ipac.caltech.edu/level5/March04/Mushotzky/Mushotzky4.html, 6. Boquien et al 2019, 7. Lacy et al 2004, 8. Stern et al 2012, 9. Donley et al 2012, 10. Messias et al 2012, 11. A multi-wavelength image of radio galaxy Centaurus A. (Image credit: X-ray: NASA/CXC/SAO; optical: Rolf Olsen; infrared: NASA/JPL-Caltech; radio: NRAO/AUI/NSF/Univ.Hertfordshire/M.Hardcastle)