Multi-Wavelength and Morphological Properties of X-ray Selected AGN and Host Galaxies in the GOODS Fields

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Introduction

Active Galactic Nuclei (AGN) are supermassive black holes (SMBH) at the centers of **host galaxies** growing by accreting new material. The SMBH's growth has been shown to impact the host galaxy [1]. Therefore, to study galaxy evolution, it is vital to understand the AGN's **multi-wavelength emission.** The AGN generates ultraviolet (UV) emission due to material in the accretion disk and infrared (IR) emission from the obscuring dusty torus (figure 1) Host galaxies may play a role with AGN evolution as dust from the host galaxy falls towards the AGN, continuing to feed it. To better understand the link between the AGN and the host galaxy, we study the structure of the host galaxy along with the multi-wavelength properties from the AGN.

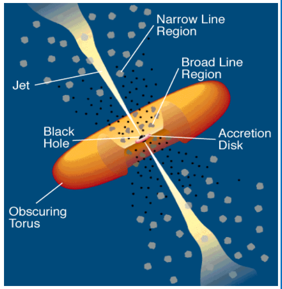


Figure 1 shows the unified model of an AGN from Urry and Padovani, 1995. Of note are the accretion disk and dusty torus where most AGN emission originates from.

Data

We utilized data from the **G**reat **O**bservatories **O**rigins **D**eep **S**urvey (GOODS) in our study. GOODS contains extensive data from X-ray to the far-infrared. We first select sources based on X-ray emission from [3] and [4]. We also took data from [3] to select multi-wavelength data to study emission properties of the AGN, focusing on the main components in the UV (accretion disk) and IR (dusty obscuring torus). The Hubble Space Telescope also observed these fields and has detailed images of the structure of the AGN host galaxies. We were then able to separate the morphologies of the host galaxies and visually classify them into six general types.

Figure 2 illustrates the GOODS South field as imaged by the Hubble Space Telescope. We utilized these observations to determine the structure of the AGN host galaxies in our sample. Hubble provided deep images showing many faint features of the galaxies.

Characteristic SED Shapes

- Spectral energy distributions display the emission from the AGN at different wavelengths.
- Utilize multi-wavelength data to bin AGN into four distinct categories based off the strength of the emission based on the UV and MIR
- There is a general trend of **decreasing X-ray emission** from the top to bottom indicating weaker or more obscured AGN.
- How does the host galaxy change for these different emission properties?

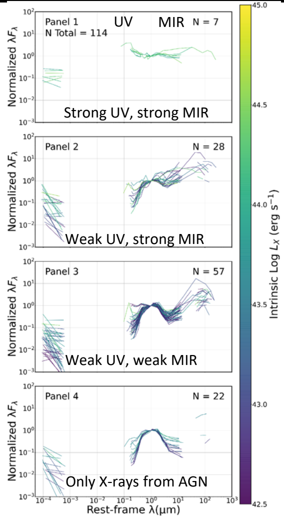


Figure 3 shows four panels of SEDs sorted based on UV and MIR emission.

Morphological Classifications

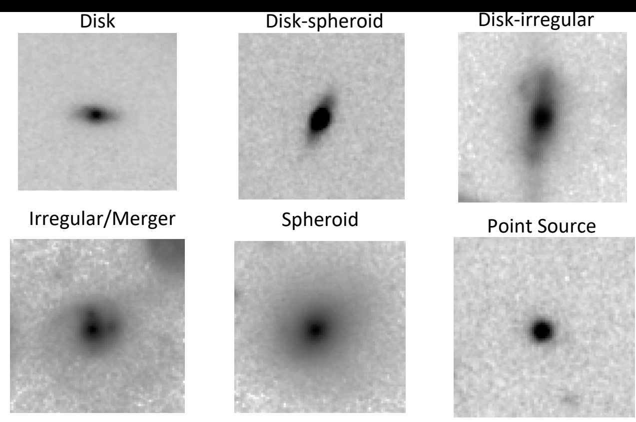
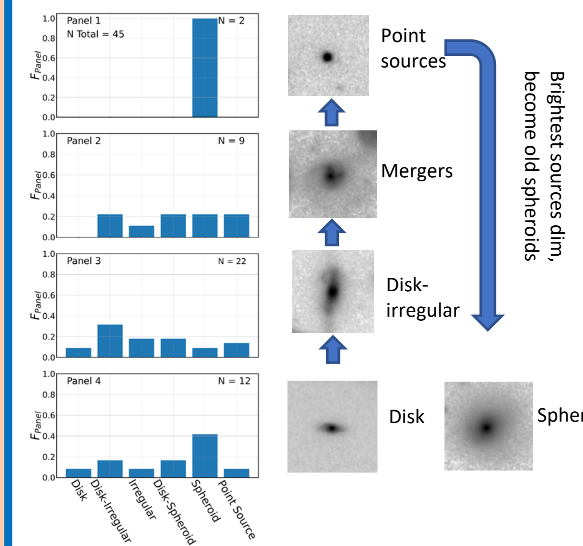


Figure 4: Six morphological types that sample galaxies were visually classified into.

Bulge-Disk Evolution



- Morphologies are classified into the same four panels as figure 3.
- Between panels 2 and 3, irregular disks and irregulars become more spheroidal, hinting that disks evolve via irregulars into spheroids.
- MIR emission increases between panels 2 and 3, implying the galaxy mergers are impacting AGN emission.
- Panel 1 shows the brightest, quasar like sources.
- Spheroids in panel 4 are likely near the end of their AGN cycle. They likely were some of the brightest sources but have dimmed over time.

Conclusions

- **Deep observations of the GOODS fields are optimized for detecting lower-luminosity and obscured AGN.**
- **Bulge growth is linked to increased UV, MIR, and X-ray emission from increased AGN activity.**
  - **Bulge growth driven by galaxy-galaxy interactions.**
- **The majority of panel 4 sources appear to be the end-stage of AGN activity.**

[1] Kormendy, J., & Ho, L. C. 2013, ARA&A, 51, 511,doi: 10.1146/annurev-astro-082708-101811
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[3] Guo, Y., Ferguson, H. C., Giavalisco, M., et al. 2013, ApJS,207, 24, doi: 10.1088/0067-0049/207/2/24
[4 Luo, B., Brandt, W. N., Xue, Y. Q., et al. 2017, ApJS, 228,2, doi: 10.3847/1538-4365/228/1/2
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