Towards a Complete Census of AGN Activity in the Local Universe: A Large Population of Optically-Unidentified AGNs

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Outstanding Questions of local AGN Activity...

1) How many local galaxies host AGN activity?
2) What are the host galaxy properties?
3) Obscured/Unobscured Ratio?
4) Contribution to IR & X-ray backgrounds?
5) Present-day growth rate of SMBHs?
Local Optically Identified AGNs

- Magnitude-limited optical spectroscopic survey ($B_T < 12.5$ mag) - Ho et al. (1997)
- Palomar (5m class) telescope 486 objects high-quality optical spectra
- ~10% of local gals host AGN activity (i.e. Seyfert gals), hosted in predominantly early-type systems (E - Sbc)
- Optical AGN detection depends strongly on morphological type (< 20% in Sc or later)....biased against dust-rich bolometrically luminous systems
Optically Unidentified AGNs

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- Revised Bright Galaxy Survey (RBGS; Sanders et al. [2003])
- 68 IR-bright objects to $D < 15\text{Mpc}$ - $L_\text{IR} \gtrsim 3 \times 10^9 L_\odot$
- 64 with high-resolution Spitzer-IRS (~94% Complete)
- Missing gals -
  - NGC3486 (Sy2)
  - NGC4565 (Sy2)
  - NGC5248 (HII)
  - NGC5457 (HII)  
  - Ho et al. (1997; Ho97)
Spitzer-IRS Volume-Limited Sample

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IR Fine-Structure Lines & Unambiguous AGN Indicators

IR fine-structure lines are the best tool to separate different regimes: they cover the parameter space well and do not suffer from heavy extinction.

\([\text{Ne}^+V] (97.1 \text{ eV})\)

Unambiguous AGN Activity Indicator
Mid-IR Spectral Diagnostics (II)

Wavelength (microns)

Flux density (ergs/s/cm²/micron)

M82
Opt: HII
MIR: SB
PAH
[CIII]

NGC1068
Opt: Sy2
MIR: AGN
[NeV]

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Mid-IR & Optical Classifications

- **Optical** AGN fraction: ~ 11%
- 17 / 64 galaxies with [NeV] detections...
  - **mid-IR** AGN fraction: ~ 27±7%
- 7 mid-IR AGNs have sensitive optical spectroscopy in Ho97
- 3 / 7 are **NOT** identified as AGN in Ho97
- 11 objects without optical spectroscopy (2 mid-IR AGNs)
- AGNs span a wide range of late-type galaxy morphology (S0-Irr)
Why are these new AGNs not identified at optical wavelengths?

1) Are new mid-IR AGNs intrinsically lower luminosity than optical Seyferts?
2) Optical emission diluted by strong circumnuclear star-formation?
3) Host galaxy dust obscuration?
• [NeV] is a good tracer of bolometric luminosity of the AGN (Dasyra et al. 2008)

• Highly-luminous AGNs ($L_{[NeV]} > 10^{39}$ erg s$^{-1}$) are readily identified at optical wavelengths

• Majority of optically unidentified AGNs are more luminous than some optical Seyferts
Are Optical AGN signatures diluted by strong Starburst Activity?

- Mid-IR Continua of Starburst gals are characterised by strong PAH features (λ ~ 3.1, 7.7, 11.2, 14.2 and 17.0 μm)

Genzel et al. 1998

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Are Optical AGN signatures diluted by strong Starburst Activity?

- $[\text{NeV}]$ (97.1 eV) good indicator of AGN activity
- $[\text{NeII}]$ (21.6 eV) good indicator of SF activity
- Many optically unidentified AGNs are SF dominated (AGN contribution < 10%)
- Some optical Seyferts are also SF dominated!

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Why are these new AGNs not identified at optical wavelengths?

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Are Optically Unidentified AGNs heavily dust-obscured objects?

Increased H\(\beta\) flux from young stars shifting gals out of Seyfert region of BPT

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Many late-type galaxies are dust/gas rich

Optical Seyferts have little absorption in [OIII] flux & suffer only moderate extinction in Balmer decrements: $A_V \sim 0 - 3$ mags

Optically unidentified AGNs:

- little extinction - possibly an increase in H$\beta$ flux from young stars?
- heavily extinct in [OIII]: $A_V \sim 3 - 9$ mags

Where is the additional extinction?
Extinction in the Host Galaxy?
Extinction in the Host Galaxy?

Optically Unidentified AGNs

Optically Unidentified AGNs

Optical Seyferts

Optically Unidentified AGNs

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• First volume-limited Spitzer-IRS search for AGN activity in the most bolometrically luminous galaxies to D<15 Mpc

• 17 of 64 galaxies in our survey host AGN activity, i.e., AGN fraction of ~27%

• ~50% of AGNs are missed in sensitive optical surveys

• Optically unidentified AGNs span a wide range of late-type galaxies, S0 - Sd, ~40% are in pseudo-bulge Sc-Sd. ...classical bulge not a necessary component to grow a SMBH???

• Majority of optically unidentified AGNs reside in highly-inclined/heavily dust-obscured galaxies OR star-bursting galaxies