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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...

- I) 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







Spitzer-IRS Volume-Limited Sample

- Revised Bright Galaxy Survey (RBGS; Sanders *et al.* [2003])
- 68 IR-bright objects to D < 15Mpc - $L_{\rm IR} \gtrsim 3 \times 10^9 L_{\odot}$
- 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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- **Revised Bright Galaxy Survey** (RBGS; Sanders et al. [2003])
- 68 IR-bright objects to $D < I5Mpc - L_{IR} \gtrsim 3 \times 10^9 L_{\odot}$
- 64 with high-resolution Spitzer-IRS (~94% Complete)
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Mid-IR Spectral Diagnostics







IR Fine-Structure Lines & Unambiguous AGN Indicators







Mid-IR Spectral Diagnostics (II)



Wavelength (microns)





Mid-IR & Optical Classifications

- **Optical** AGN fraction : ~ II%
- I7 / 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
- I I objects without optical spectroscopy (2 mid-IR AGNs)
- AGNs span a wide range of latetype galaxy morphology (S0-Irr)







Why are these new AGNs not identified at optical wavelengths?

- I) 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?





Are Optically Unidentified AGNs Intrinsically Lower Luminosity?

- [NeV] is a good tracer of bolometric luminosity of the AGN (Dasyra et al. 2008)
- Highly-luminous AGNs (L_[NeV] > 10³⁹ 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 ($\lambda \sim 3.1, 7.7, 11.2, 14.2$ and 17.0 µm)



Are Optical AGN signatures diluted strong Starburst Activity?



- **[NeV]** (97.1 eV) good indicator of AGN activity
- [Nell] (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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Are Optically Unidentified AGNs heavily dust-obscured objects?



Are Optically Unidentified AGNs heavily dust-obscured objects?

- 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 ~ 0 - 3 mags
- Optically unidentified AGNs:
 - Ittle extinction possibly an increase in Hβ flux from young stars?
 - heavily extinct in [OIII]:
 A_V ~ 3 9 mags



Where is the additional extinction?



Extinction in the Host Galaxy?







Extinction in the Host Galaxy?







Conclusions

- First volume-limited Spitzer-IRS search for AGN activity in the most bolometrically luminous galaxies to D<15 Mpc
- I7 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 highlyinclined/heavily dust-obscured galaxies
 OR star-bursting galaxies



