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A study of optical/IR selected AGNs with SDSS and WISE

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Abstract. We analyze a sample of 30,000 nearby obscured AGNs with SDSS and WISE. We use a "pair-matching" technique to subtract the host 4.6 μm contribution, with the aid of SDSS data. By combining Seyferts with local SDSS quasars, we show that the [OIII] and the intrinsic AGN 4.6 μm luminosities correlate roughly linearly over 4 orders of magnitude, despite of large scatter. We also compare the *partition functions* of the total integrated 4.6 μm and [OIII] line luminosities from Seyferts and IR-bright LINERs, as function of a variety of host galaxy properties. The result suggests the optical and the IR selected AGNs represent the same galaxy population. We further study the environment of the AGNs, finding a link between the IR nuclear emission and the galaxy interaction.

Keywords. galaxies: active; galaxies, nuclei; infrared: galaxies.

1. Introduction

Type 2 AGNs play an important role in the study of AGN host galaxies. Only in obscured AGNs it is possible to extract the detailed host galaxy properties, e.g. stellar masses, stellar populations and Hubble types. However, the estimation of the accretion rate becomes more complicated when the accretion disk continuum is not observable. Various AGN activity indicators, usually in form of "processed" emission, can be used to separate AGNs from normal galaxies, but biased in some fashion. Multi-wavelength approach is important.

Previous studies using [OIII] emission line as AGN activity indicator, have systematically studied the host properties of local AGNs (Kauffmann *et al.* 2003; Heckman *et al.* 2004; Kauffmann & Heckman 2009). The purpose of our study is to check whether these conclusions are still valid when the AGNs are selected in a very different way, i.e. using different AGN indicators. This kind of tests between different AGNs have been done for small samples (e.g., Hickox *et al.* 2009). In this study, we try to extract nuclear mid-IR emission, which is from obscuring torus with size of a few parsecs (e.g., Jaffe *et al.* 2004; Hönig *et al.* 2012), for a large sample of local AGNs, and investigate the host properties in IR view. Our analysis is based on stellar mass complete samples, compiled from SDSS spectroscopic sample, with WISE coverage. The selection biases are well considered.

2. Nuclear mid-IR luminosity

All WISE colors are affected by both AGN activity, indicated by $L[\text{OIII}]/M_{\text{BH}}$, and host star formation, indicated by 4000 Å break strength $D_n(4000)$. Statistically we find $[3.4] - [4.6]$ is a good AGN indicator, relatively sensitive to AGN and insensitive to star formation. The host mid-IR emission can be well determined by stellar masses and 4000 Å break strengths. We estimated the host component by matching the AGNs with inactive galaxies in stellar mass, 4000 Å break, redshift and stellar mass surface density. The

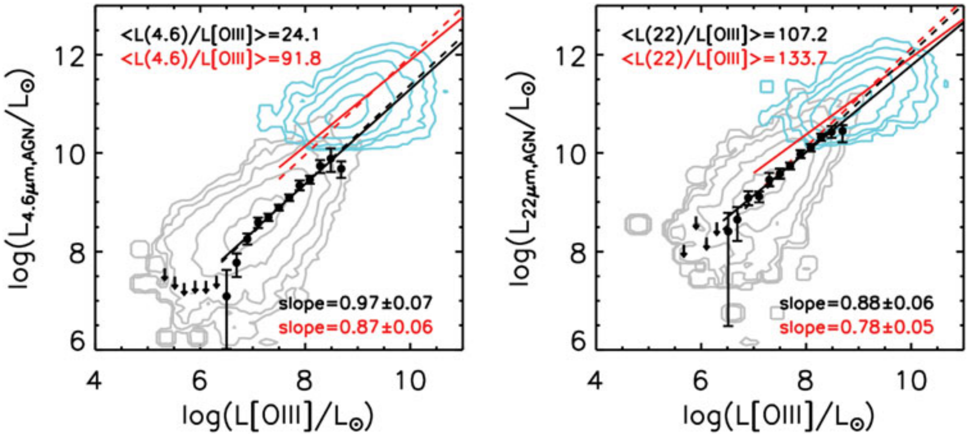

Figure 1. Left: 4.6 μm AGN luminosity versus [OIII] luminosity for Seyferts. The grey and cyan contours are Seyferts (with positive AGN 4.6 μm luminosity) and SDSS quasars respectively. The black dots and upper limits show unbiased stacking results. The black solid line is a linear fit to the black dots and the resulting slope is shown in bottom-right corner. The black dashed line is a linear fit assuming the 4.6 μm luminosity is proportional to [OIII] luminosity. The median value of the IR-to-[OIII] ratio is shown on top-left corner. The red lines are similar to black ones but for SDSS quasars. Right: similar to the left panel, except the 22 μm luminosities are used and the result is from a smaller well defined 22 μm flux-limited sample of Seyferts.

obtained nuclear IR luminosities are found to be well correlated with [OIII] luminosities, though the scatter is large. Figure 1 shows the correlation expands for 4 orders of magnitude if combined with a sample of SDSS quasars. Stacking is used to avoid bias from dropping off objects with negative IR luminosities.

The detection of nuclear IR emission is not possible at $L_{4.6\mu m} \lesssim 3 \times 10^8\,L_\odot$ due to heavy host contamination. The Seyfert-quasar offset is likely due to intrinsic absorption of the torus, which causes ~0.6 dex offset at 4.6 μm while is almost gone at 22 μm. The strength of the absorption is found not correlated with luminosities, and this does not affect our results.

3. Host galaxy properties in IR view

We integrate the [OIII] and 4.6 μm (no matter positive or negative) luminosities of Seyfert galaxies and check the emissivity distribution as function of a variety of host galaxy properties (see Figure 2). The [OIII] emissivity distribution is consistent with previous study (Heckman *et al.* 2004). We find the red and blue histograms are identical. It suggests the [OIII] as an AGN indicator does not show biases as compared to the 4.6 μm luminosity. The [OIII] selected and mid-IR selected AGNs lead to the same AGN population.

We also find that for a sub-population of LINERs with reliable IR nuclear detections, the two distributions are still identical. That means these IR-bright LINERs (also tend to be [OIII]-bright) are “true” AGNs, and are consistent with the expectation of the simple unification model. We make no solid conclusion for the whole LINER population because the majority of LINERs are too weak for IR detection.

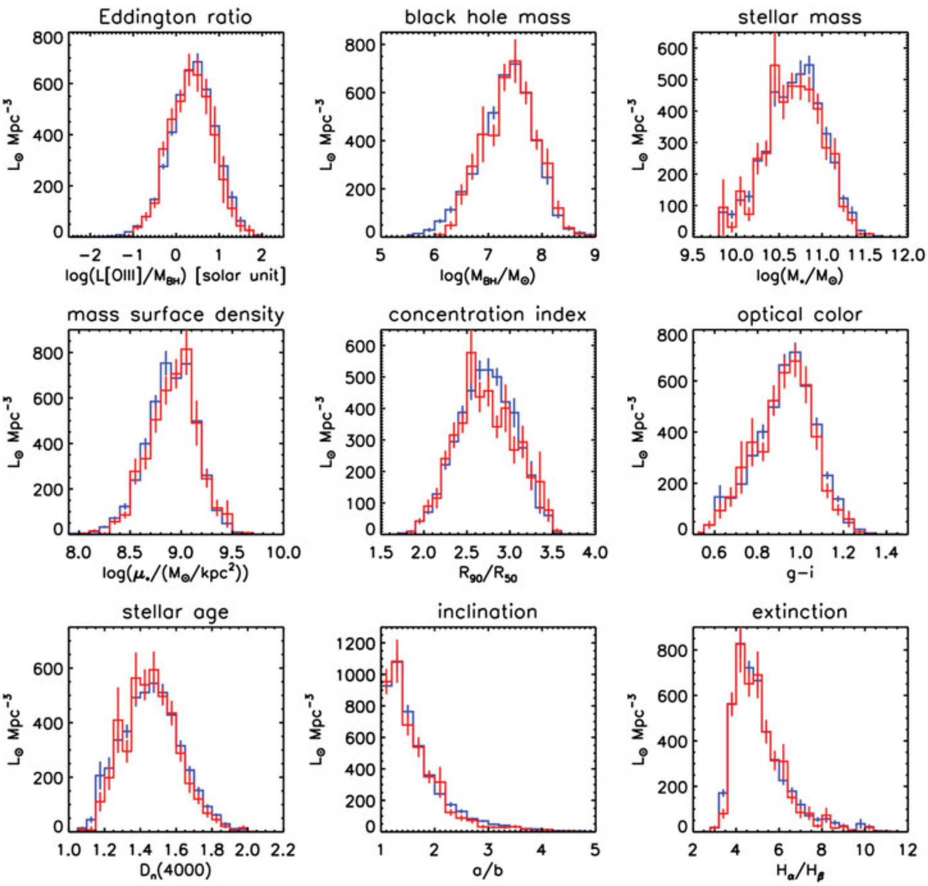

Figure 2. The total [OIII] and IR emissivity as a function of various AGN properties for Seyferts. The blue histogram is for the [OIII] luminosity density and the red histogram is for the 4.6 μm luminosity density. The red histogram is scaled down by a factor of 24.1 to compensate the constant 4.6 μm-to-[OIII] ratio calibrated in left panel of Figure 1.

4. Environment of IR AGNs

We further check the environment of IR AGNs, and compare to [OIII] selected ones. We use the technique adopted by Li *et al.* (2006) to estimate the number of companions around AGNs. The whole local AGN sample is binned by different ways, e.g. [OIII] luminosities, mid-IR luminosities and so on, for comparison. In each binning way, subsamples are carefully matched at similar stellar masses and stellar age, to remove the effect of star formation on clustering properties.

As preliminary result, we find that on average the IR-strong AGNs have more close neighbours than IR-weak AGNs, on scale of 10 to 100 kpc, while [OIII]-strong AGNs do not show similar feature. The difference between [OIII] and IR emission implies the change of torus obscuration properties, i.e. the AGNs with close neighbours have larger torus covering factor than isolated AGNs. Theoretical study suggests the torus formation/thickening occurs during the cold gas inflow (e.g., Hopkins *et al.* 2012). If this is true, then the nuclear activities in some AGNs are directly linked with galaxy interactions. However, these objects only occupy a very small fraction of the whole AGN population. Hence this result is not necessarily contradictory with our conclusion made in previous section.

5. Summary

We have successfully subtracted the host component in mid-IR bands in a statistical way. We have established a correlation between the nuclear mid-IR luminosities and the [OIII] emission line luminosities. Within the luminosity range of our local AGN sample, we find the host galaxies are similar for optical and IR selected AGNs. We have revealed a link between AGN IR emission and galaxy interactions.

References

Heckman, T. M., Kauffmann, G., Brinchmann, J., Charlot, S., Tremonti, C., & White, S. D. M., 2004, *ApJ*, 613, 109

Hickox, R. C., *et al.*, 2009, *ApJ*, 696, 891

Hönig, S. F., Kishimoto, M., Antonucci, R., Marconi, A., Prieto, M. A., Tristram, K., & Weigelt, G., 2012, *ApJ*, 755, 149

Hopkins, P. F., Hayward, C. C., Narayanan, D., & Hernquist, L., 2012, *MNRAS*, 420, 320

Jaffe, W., *et al.*, 2004, *Nature*, 429, 47

Kauffmann, G. & Heckman, T. M., 2009, *MNRAS*, 397, 135

Kauffmann, G., *et al.*, 2003, *MNRAS*, 346, 1055

Li, C., Kauffmann, G., Wang, L., White, S. D. M., Heckman, T. M., & Jing, Y. P., 2006, *MNRAS*, 373, 457