Selecting Seyfert galaxies with nuclear AGN-dominated far-infrared emission

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Abstract: We present far-infrared (FIR) 70 – 500 μm imaging observations obtained with Herschel/PACS and SPIRE of 33 nearby (median distance of 30 Mpc) Seyfert galaxies from the Revised Shapley-Ames (RSA) catalogue. We obtain the FIR nuclear (r = 1 kpc and r ≥ 2 kpc) and integrated spectral energy distributions (SEDs). We estimate the unresolved nuclear emission at 70 μm and we fit the nuclear and integrated FIR SEDs with a grey body model. We find that the integrated FIR emission of the RSA Seyferts in our sample is dominated by emission from the host galaxy, with dust properties similar to those of normal galaxies (non AGN). We use four criteria to select galaxies whose nuclear 70 μm emission is dominated by the AGN: (1) elevated 70/160 μm flux ratios, (2) spatially resolved, high dust temperature gradient, (3) 70 μm excess emission with respect to the fit of the FIR SEDs with a grey body, and (4) excess of nuclear SFR obtained from 70 μm SEDs from mid-IR to far-IR. We satisfy at least one of these conditions, whereas 10 satisfy half or more. After careful examination of these, we select six bona fide candidates (18 per cent of the initial sample) and estimate that ~ 40 – 70 per cent of their nuclear (r = 1 – 2 kpc) 70 μm emission is contributed by dust heated by the AGN.

1. Comparison of our sample and the galaxies in Diamond-Stanic & Rieke (2012)

We select three galaxies with higher dust temperature gradient than the typical values in our sample.

2. Example of the Herschel/PACS and SPIRE mosaics of IC 5063

We select nine galaxies with this criterion.

3. Identifying galaxies with significant 70 μm emission due to AGN-heated dust: 4 criteria

We select three galaxies with higher dust temperature gradient with respect to the fit of the FIR SEDs with a grey body.

4. MIR and FIR emission of the candidates to significant nuclear 70 μm AGN emission

Our sample is not statistically different in terms of the star formation rate although it only includes the most luminous AGN L_{SFR} > 2 x 10^{12} erg s^{-1} Hz^{-1} when compared to the Diamond-Stanic & Rieke (2012) RSA sample. This is because in general low-luminosity AGN are not bright in the mid-IR and flux measurements meet our requirement of having high angular resolution MIR spectroscopy obtained from the ground.


16 galaxies (48 per cent of the sample) satisfy at least one of the criteria, while 10 of them fit at least half of the criteria. In a more conservative, we only consider the 10 RSA Seyferts in our sample that satisfy half or more of the criteria.

We discarded two of them, NGC 4523 and M82, as both show 11.3 μm PAH emission in the inner 0.5 arcsec and high SFR within r = 1 kpc scales. This probably suggests that the elevated f_{ν} (160 μm) flux ratios are due to strong star formation rather than AGN dominated fluxes at 70 μm.

We also discarded NGC 4579 and NGC 4725. Both galaxies show a significant excess at 70 μm with respect to the β = 2 grey body fitted SED. However, if we assumed that the excess is entirely due to dust heated by the AGN, then the AGN flux at 70 μm would be similar to the measured nuclear r = 1 kpc flux for NGC 4579 and more than 20 times brighter than that arising from the nuclear region for NGC 4725.

We therefore conclude that the 70 μm nuclear emission for these two galaxies is not dominated by dust heated by the AGN.

We are left with six (18 per cent of the sample) bona fide candidates, namely, IC 5063, NGC 3783, NGC 4151, NGC 5347, NGC 7231, and NGC 7479.

CONCLUSIONS: The four criteria defined in this work provide a good way to select statistically Seyferts with significant contribution of the AGN at 70 μm using Herschel data. After the inspection of the 10 RSA Seyfert galaxies that satisfy half or more of the criteria, we select six (18 per cent of the sample) bona fide candidates and estimate that ~ 40 – 70 per cent of their nuclear (r = 1 – 2 kpc) 70 μm emission is contributed by dust heated by the AGN. We used the different criteria to estimate the range of the AGN flux at 70 μm. For each galaxy we only used the criteria satisfied. We estimated that ~ 40 – 70 per cent of their nuclear (r = 1 – 2 kpc) 70 μm emission is contributed by dust heated by the AGN.

Dust temperature gradient higher than typical star-forming galaxies

Distribution of the $f_{\nu}$(70 μm)/$f_{\nu}$(160 μm) flux ratios where the $f_{\nu}$(model) is obtained through a β=2 grey body fitting for each galaxy. The 70 μm excess with respect to the fit of the FIR SEDs with a grey body with β = 2 is not only due to star formation but that there is some contribution from the AGN.

Distribution of the 70 μm integrated fluxes calculated as $f_{\nu}$(70 μm) = $f_{\nu}$(model) - $f_{\nu}$(obs), where the $f_{\nu}$(model) is obtained through a β=2 grey body fitting for each galaxy.

Nuclear SFR (r = 1 kpc) from the 70 μm luminosity versus the 11.3 μm PAH SFR (r = 1 kpc) from DISR2012. The black line indicates the 1:1 relation. All the nuclear 70 μm based SFR are systematically higher than those obtained by Diamond-Stanic & Rieke (2012) using the 11.5 μm PAH feature luminosity. The most discrepant values of SFR could indicate that part of the nuclear 70 μm emission is due to the dust heated by the AGN instead of star formation.

Nuclear SFR (r = 1 kpc) from the 70 μm luminosity and the 11.3 μm PAH SFR (r = 1 kpc) from DISR2012. The black line indicates the 1:1 relation.

Distribution of the 70 μm integrated fluxes calculated as $f_{\nu}$(70 μm) = $f_{\nu}$(model) - $f_{\nu}$(obs), where the $f_{\nu}$(model) is obtained through a β=2 grey body fitting for each galaxy.

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