Probing accretion activity in radio sources using 24 $\mu$m Spitzer data

Eleni Vardoulaki$^1$, Steve Rawlings$^1$, Chris Simpson$^2$

$^1$ Astrophysics, Department of Physics, Denys Wilkinson Building, Keble Road, Oxford, OX1 3RH, UK
$^2$ Astrophysics Research Institute, Liverpool John Moores University, Twelve Quays House, Egerton Wharf, Birkenhead CH41 1LD, UK

Abstract. We study the 36 brightest radio sources in the Subaru/XMM-Newton Deep Field (SXDF). Using MIPS 24 $\mu$m data from Spitzer we expect to trace accretion activity, even if it is hidden at optical wavelengths, unless the obscuring column is extreme. Our results suggest that in the decade or so below the break in the radio luminosity function that at least half, and potentially nearly all, radio sources are associated with accreting quasar-like objects. This is not true at lower radio luminosities where the quasar-like fraction approaches zero once compact sources are excluded.

1. Introduction

In unified AGN models, powerful radio sources are believed to have a central source emitting in the optical, UV and X-rays. The dusty torus that surrounds the nuclear region absorbs this light and re-emits it in the infrared. This mechanism makes it difficult to observe the objects viewed through the torus directly in the optical, UV and soft X-rays. Willott et al. (2000) define the quasar fraction $f_q$ to be the ratio of unobscured to obscured quasars. In Vardoulaki et al. (2006) we expressed the need to study radio sources in the mid-infrared in order to investigate the existence of any hidden accretion activity in radio sources. Spitzer observations at 24 $\mu$m are ideal for this task, since they trace hot dust emission which can be obscured only by extreme columns (Ogle et al. 2006).

Our sample is the 36 brightest radio sources from the VLA survey of the SXDF (Simpson et al. 2006) with flux densities greater than 2 mJy at 1.4 GHz. Most of our objects are not as yet spectroscopically confirmed, so we use photometric redshifts for our analysis. We use a radio spectral index $\alpha = 0.8$ ($S_\nu \propto \nu^{-\alpha}$). We assume throughout a low-density, $\Lambda$-dominated Universe in which $H_0 = 70$ km s$^{-1}$Mpc$^{-1}$, $\Omega_M = 0.3$ and $\Omega_\Lambda = 0.7$.

More details of this work will appear in Vardoulaki et al. (in prep.).

2. Discussion

We have constructed spectral energy distributions (SEDs) for our SXDF sample and fitted Bruzual-Charlot galaxy templates using the HyperZ photometric code (Bolzonella et al. 2000) to estimate photometric redshifts. An example is shown
Figure 1. Left: Observed frame SED of sxds_0033 with a redshift estimated using HyperZ and data from Spitzer, UKIDSS and SXDF surveys. Right: log_{10}(L_{1.4GHz}) versus largest projected linear size D: possible quasar-like objects have upper limits on \(\lambda L_{24\mu m}\) consistent with \(\lambda L_{24\mu m} > 10^{37.3}\) W.

on the left side of Fig. 1. This object is spectroscopically confirmed at redshift \(z = 1.095\). From its SED we can see excess emission at 24 \(\mu\)m, indicating that this object has hidden accretion activity. This object is not a spectroscopically confirmed quasar but has high-excitation narrow lines in its optical spectrum; its radio map shows an unresolved source.

We define objects to be 'quasar-like' when their rest-frame luminosity at \(\lambda = 24 \mu m\) is \(\lambda L_{24\mu m} > 10^{37.3}\) W, since this corresponds to \(\lambda L_{24\mu m} > 10^{-1.8}L_{Edd}\) for a quasar with \(M_{BH} \gtrsim 10^8 M_\odot\) (see McLure & Dunlop 2004, McLure et al. 2004). The luminosity at 24 \(\mu\)m is calculated using the spectral index measured from 24 \(\mu\)m to the nearest lower-\(\lambda\) detection in the observed frame SED. The quasar-like fraction \(q_l\) in the region between the RLF break and the FRI/II break is high, \(q_l \sim 0.5 - 0.9\), depending on how many of the 24 \(\mu\)m upper limits turn out to be close to detections. [The most radio luminous of the two non-quasar-like objects, is an FRI at \(z \sim 0.7\). Recall that \(f_q \sim 0.2\) in this region (Willott et al. 2000), i.e. the 24 \(\mu\)m data have revealed at least some hidden accretion activity.

The quasar-like fraction drops significantly below the FRI/II break, and if one excludes compact (\(D < 100\) kpc) sources as potentially part of a separate (beamed) population, we see that there are no definite quasar-like objects.

We conclude that Spitzer 24-\(\mu\)m data on the SXDF radio sources are consistent with the hypothesis that quasar-like objects are almost always associated with powerful (above the FRI/II break) radio sources, but are rarely connected to less luminous sources, unless they are part of the compact population.

References

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