Perseus in Sicily: From Black Hole to Cluster Outskirts
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Infrared Diagnostics of the ISM in the Circumnuclear Environments of the Youngest Radio Galaxies

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Abstract. Here we present a systematic analysis of the mid-infrared properties of young radio galaxies, based on lower-resolution data provided by WISE and IRAS satellites. We restrict our analysis to sources in the earliest phase of radio galaxy evolution, with corresponding ages of the radio structures $\leq 3,000$ yrs. In our sample of 29 objects, we find a variety of WISE colors, which suggests that the mid-infrared continua of studied sources are not exclusively contributed to by the circumnuclear dust. A comparison of the total mid-infrared and absorption-corrected X-ray luminosities for our sample reveals a clear correlation between the two bands. This favors the scenario in which the observed X-ray emission of young radio galaxies — at least the high-luminosity ones — originates predominantly in accretion disk corona.

Keywords. ISM: jets and outflows— galaxies: active— galaxies: jets— infrared: galaxies— X-rays: galaxies

1. Introduction

Young radio sources constitute a particularly interesting yet diverse class of active galactic nuclei (AGN), with newly born radio structures (jets and lobes) fully confined within their host galaxies. We focus on a systematic investigation of the mid-infrared (MIR) properties of the youngest radio galaxies. Sources have been confirmed spectroscopically in the radio domain as 'GHz-peaked spectrum' (GPS) sources, and/or morphologically (using high-resolution radio interferometers) as 'compact symmetric objects' (CSOs), using the data provided by the Wide-field Infrared Survey Explorer (WISE), as well as the archival data from the Infrared Astronomical Satellite (IRAS) augmented in a few cases by the *Spitzer* Space Telescope observations.

2. Discussion & Conclusions

In Figure 1 (left), all objects in the sample confirmed as Compton-thick based on the X-ray spectroscopy (1404+286, 1511+0518 and 2021+614; see Guainazzi *et al.* 2004; Siemiginowska *et al.* 2016; Sobolewska *et al.* 2018, respectively), are characterized by the WISE colors consistent with the quasar identification, as in fact expected. The most striking feature of the diagram is, however, the fact that the youngest radio galaxies with colors W1–W2 ≤ 0.5 mag, i.e. those dominated in MIR by the ISM radiative output, populate almost the entire region occupied by galaxies (from elliptical to starbursts) with the W2–W3 colors between 1.0 and 4.0, meaning a wide range of star formation activity within their hosts.

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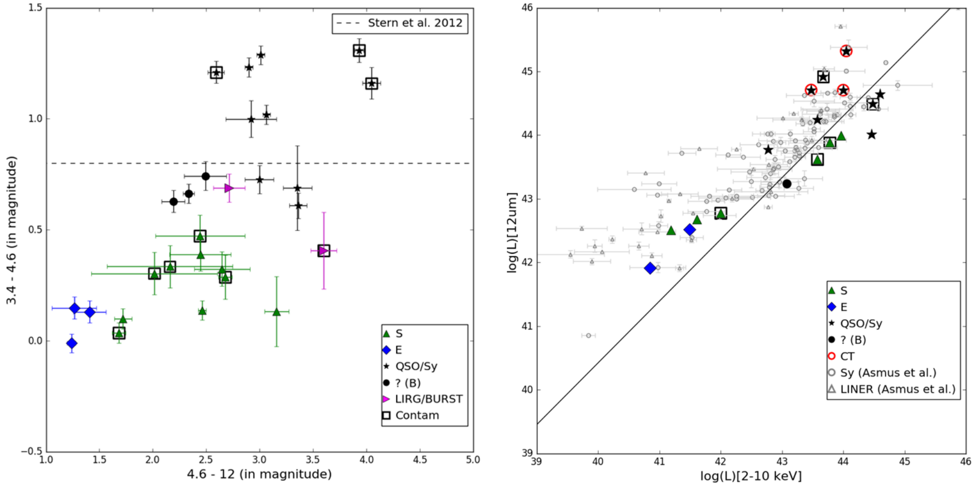

Figure 1. (Left) WISE color magnitudes for young radio galaxies included in our sample. Different symbols denote WISE color classification following Wright *et al.* (2010); sources marked with a black square may have significant contamination from nearby objects; red circles indicate objects confirmed as Compton-thick. The horizontal line delineates Stern *et al.* (2012) cut: the MIR emission of sources located above the line are dominated by an AGN component. (Right) Relation of the IRAS 12 μm and the intrinsic (absorption-corrected) 2–10 keV luminosities for our young radio galaxies denoted by large symbols (same as in the image on the left). The solid line shows the correlation established for nearby AGN by Asmus *et al.* (2015) based on the high-angular resolution MIR (ground-based) observations; small gray symbols denote the AGN from the Asmus *et al.* (2014) sample with IRAS 12 μm luminosities.

In Figure 1, right, we plot the IRAS 12 μm and the intrinsic (absorption-corrected) 2–10 keV luminosities for the sample of our young radio galaxies, along with a comparison sample of Seyfert galaxies and LINERs from Asmus *et al.* (2014), for which the 12 μm luminosities were obtained similarly with the IRAS satellite. In the cases of two young radio galaxies for which the IRAS 12 μm were not available, we used the *Spitzer*/MIPS 24 μm luminosities instead; note that the $\sim 6''$ MIPS resolution at 24 μm, is comparable to the IRAS angular resolution of $\sim 30''$ at 12 μm. The AGN from the comparison sample are located mostly above the best-fit correlation line: this is because with the relatively poor angular resolution of IRAS, the MIR luminosities derived for the sample are contributed not only by the circumnuclear dust emission, but also by the star formation activity within the host galaxies, while the best-fit correlation was established based on sub-arcsec MIR photometry, so without any significant ISM emission component.

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