Highlights on Spanish Astrophysics IX, Proceedings of the XII Scientific Meeting of the Spanish Astronomical Society held on July 18 – 22, 2016, in Bilbao, Spain. S. Arribas, A. Alonso-Herrero, F. Figueras, C. Hernández-Monteagudo, A. Sánchez-Lavega, S. Pérez-Hoyos (eds.)

The mid-infrared emission of a complete sample of Seyfert galaxies

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Abstract

We present subarcsecond resolution mid-infrared (MIR) images obtained with 8-10 m-class ground-based telescopes of a complete volume-limited (D_L <40 Mpc) sample of 24 Seyfert galaxies selected from the *Swift/BAT* nine month catalog. We use those MIR images to study the nuclear and circumnuclear emission of the galaxies. Using different methods to classify the MIR morphologies on scales of ∼400 pc, we find that the majority of the galaxies (75-83 %) are extended or possibly extended and 17-25% are point-like. This extended emission is compact and it has low surface brightness compared with the nuclear emission, and it represents, on average, ∼30 % of the total MIR emission of the galaxies in the sample. We find that the galaxies whose circumnuclear MIR emission is dominated by star formation show more extended emission (650±700 pc) than AGN-dominated systems (300±100 pc). In general, the galaxies with point-like MIR morphologies are face-on or moderately inclined (b/a ∼0.4-1.0), and we do not find significant differences between the morphologies of Sy1 and Sy2. We used the nuclear and circumnuclear fluxes to investigate their correlation with different AGN and SF activity indicators. We find that the nuclear MIR emission (the inner ∼70 pc) is strongly correlated with the X-ray emission (the harder the X-rays the better the correlation) and with the [O IV] λ25.89 μm emission line, indicating that it is AGN-dominated. We find the same results, although with more scatter, for the circumnuclear emission, which indicates that the AGN dominates the MIR emission in the inner ∼400 pc of the galaxies, with some contribution from star formation.

1 Introduction

Active galactic nuclei (AGNs) are powered by accretion of material onto supermassive black holes (SMBHs), which release enormous quantities of energy in the form of radiation and/or mechanical outflows to the host galaxy interstellar medium. This feedback is fundamental to the formation and evolution of the host galaxies [7]. The unified model [1] proposes that there is dust surrounding the active nucleus distributed in a toroidal geometry, which obscures the central engines of type 2, and allows a direct view in the case of type 1 sources. The dusty torus absorbs the AGN radiation and, then, reprocesses it to emerge in the infrared (IR), peaking in the mid-IR (MIR; ∼5–30 μm), according to torus models (e.g. [11, 12]).

The unprecedented angular resolution achieved by 8–10 m-class ground-based telescopes in the MIR is crucial to correctly separate the nuclear emission from the foreground galaxy emission. As the MIR-emitting torus is compact (r <10 pc; see e.g. [3]), this angular resolution is fundamental to isolate its emission from other emitting sources at larger scales, as well as to disentangle the heating source of the diffuse circumnuclear MIR emission. However, our understanding about the dominant heating source of the dust on these physical scales (inner kpcs) remains unclear, because of the paucity of ground-based MIR instruments and the limited size of the samples studied to date [8, 4, 9, 10, 6]. A major step forward was attained with the publication of the subarcsecond MIR imaging atlas of local AGN [2].

The aim of this work is to study for the first time the nuclear and circumnuclear MIR emission of a complete and volume limited sample of X-ray selected Seyfert galaxies to obtain statistically significant results.

2 Results

In this work we present the first detailed study of the nuclear and circumnuclear MIR emission of a complete sample of Seyfert galaxies (24 galaxies; BCS_{40} sample) selected in the X-rays using high angular resolution images from 8–10 m-class ground-based telescopes. Here we used the nine month *Swift/Burst Alert Telescope* (BAT; [13]) AGN catalog, which is a very hard X-ray survey (14–195 keV), to select our AGN sample. See [5] for further details.

Taking advantage of the angular resolution provided by the ground-based instruments, we obtained MIR nuclear fluxes for all the galaxies in our sample using the PSF subtraction method. Once we obtained the subarcsecond resolution MIR nuclear fluxes (hereafter nuclear fluxes), we can quantify the circumnuclear MIR emission of the galaxies by subtracting the nuclear emission from the total fluxes.

Using different methods (visual and quantitative classification) to classify the MIR morphologies on scales ∼400 pc using ground-based MIR images for each galaxy, we found practically the same results, that the majority of the sample show extended or possibly extended morphologies. We found that the galaxies with point-like MIR morphologies are face-on or moderately inclined (b/a ∼0.4–1.0). From this classification, we found that the extended MIR emission is compact and it has low surface brightness compare with the nuclear emission. This extended emission represents, on average, ∼30 % of the total emission in our

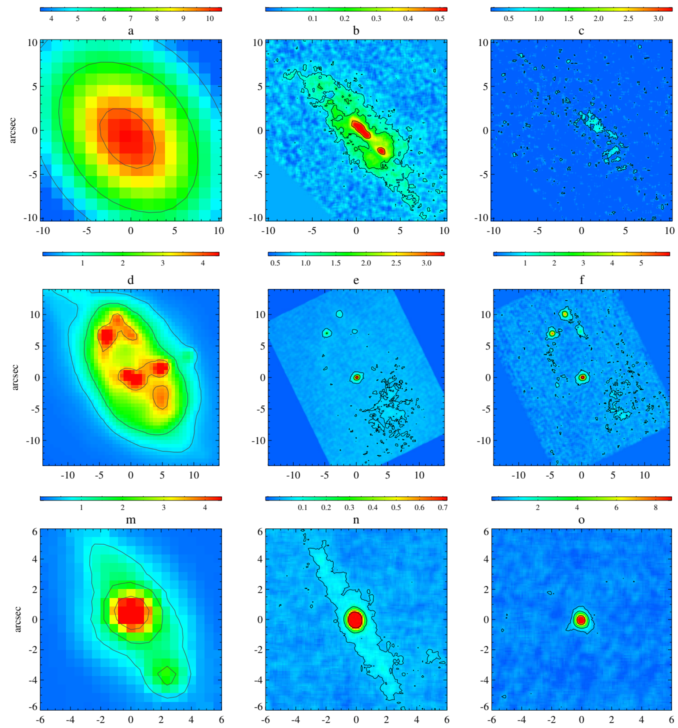

Figure 1: Examples of galaxies showing extended MIR emission on scales larger than 400 pc in the high angular resolution data: NGC 4945, NGC 1365 and NGC 2992.

sample. On the other hand, we found that the extended MIR emission in AGN-dominated systems is more compact (300±100 pc) than in SF-dominated systems (650±700 pc) and composite galaxies (350±500 pc).

Despite the fact that a large fraction of the sample (∼80%) show extended morphologies, most of this extended emission is compact and concentrated close to the nuclear region. Only six Sy2 galaxies in our sample present extended MIR emission at large-scales (>400 pc) in the high angular resolution MIR data (see Fig. 1): NGC 1365, NGC 2992, NGC 3081, NGC 4945, NGC 5506 and NGC 7582. We compare this large-scale MIR emission detected in the high angular resolution data with the lower resolution data of Spitzer or WISE. This extended emission detected in the high angular resolution data has similar structure and orientation than those detected in the lower resolution data. For 4/6 of these galaxies the bulk of this extended emission is due to SF activity.

Finally, we found a strong correlation between the nuclear MIR emission of the sample and the different AGN indicators. The tightness of the correlations between the nuclear MIR emission and both the X-rays (see left panel of Fig. 2) and [O IV], as well as the less significant correlation with the [Ne II]$_{SF}$ confirm that the nuclear emission of the inner ∼70 pc of our sample is AGN-dominated. We found practically the same, although with larger scatter, for the circumnuclear emission (see right panel of Fig. 2). This suggest that the AGN dominates the MIR emission in the inner ∼400 pc of the galaxies, although with some contribution from

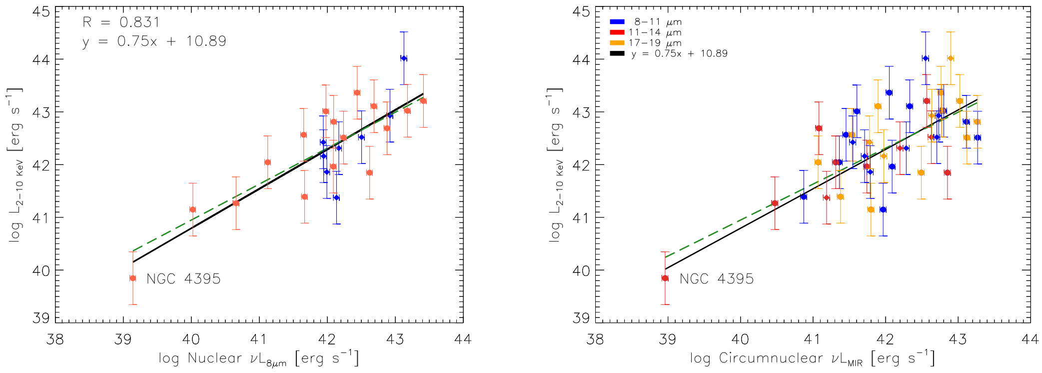

Figure 2: High angular resolution MIR–X-ray luminosity correlations. Left panel: 8 μm nuclear luminosity versus intrinsic 2–10 keV X-ray luminosity. Right panel: Same as in the left panel, but for the circumnuclear MIR luminosities.

SF for the galaxies deviating more from the nuclear correlations.

Acknowledgments

IGB acknowledges financial support from the Instituto de Astrofísica de Canarias through Fundación La Caixa. IGB acknowledge financial support from the Spanish Ministry of Science and Innovation (MICINN) through project PN AYA2013-47742-C4-2-P.

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