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A MID-IR SURVEY OF LOCAL AGN WITH GTC/CANARICAM

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RESUMEN

Presentamos una exploración en el infrarrojo medio (MIR) de una muestra de AGN cercanos usando CanariCam en el Gran Telescopio Canarias (GTC). Se van a obtener imágenes y espectroscopía de unos 100 AGN cubriendo seis órdenes de magnitud en luminosidad del AGN y diferentes tipos (p.e., LINERs, Seyfert 1s y 2s, QSO). Los objetivos principales son: (1) testear el modelo unificado para AGN de Tipos 1 y Tipos 2, (2) estudiar la formación estelar alrededor de AGN y (3) explorar el papel del toro de polvo en AGN de baja luminosidad.

ABSTRACT

We describe a mid-infrared (MIR) survey of local AGN to be conducted with the CanariCam instrument on the Gran Telescopio Canarias (GTC). We will obtain MIR imaging and spectroscopy of a sample of ∼100 AGN covering six orders of magnitude in AGN luminosity, and including different AGN classes (e.g., LINERs, Seyfert 1s and 2s, QSO). The main goals are: (1) to test unification of Type 1 and Type 2 AGN, (2) to study the star formation activity around AGN and (3) to explore the role of the dusty torus in low-luminosity AGN.

Key Words: galaxies: active — galaxies: star formation — infrared: galaxies

1. INTRODUCTION

Active galactic nuclei (AGN) are powered by accretion of gas onto a supermassive ($10^6 - 10^9$ $M_\odot$) black hole. The Unified Model (Antonucci 1993) explains the observed differences between AGN classified as Type 1 and Type 2 –notably the presence or absence of broad optical emission lines– in terms of geometry. The central engines of Type 1 AGN are viewed directly. In the Type 2 views, an optically and geometrically thick "torus" of material in the inner region hides the active nucleus and broad emission-line region. Moreover, unification is extended to encompass both radio quiet (RQ) and radio loud (RL) objects, which exhibit either a low or high ratio of optical to radio luminosity, respectively (Urry & Padovani 1995).

Whilst critical to the Unified Model of AGN, the torus itself remains poorly constrained. Since torus models agree that the torus peaks at mid-infrared (MIR, ∼8–26 μm) wavelengths, MIR observations offer the best opportunity for progress in constraining the torus models. Although the pc-scale torus can only be resolved with interferometric observations, this technique can only be used for a few very bright and nearby sources (Tristram et al. 2009), definitely not enough for any statistical investigation. The MIR angular resolution of 8–10 m class telescopes although is not sufficiently high to spatially resolve the torus structure, it can help disentangle the torus emission from the circumnuclear and host galaxy contribution, as well as from the emission of the narrow line region (Radomski et al. 2003; Packham et al. 2005; Roche et al. 2006). This is most relevant for modeling the properties of the torus, as in the past the use of MIR large aperture measurements resulted in a confused picture of the torus, accretion, and interaction with the host galaxy.

2. THE SURVEY

We will be carrying out a MIR survey of a sample of local AGN using the CanariCam (Telesco et al. 2003) instrument on the Gran Telescopio Canarias (GTC). The observations will be taken as part of the guaranteed time of the CanariCam AGN Science Team and an ESO/GTC large programme. We used the hard (2–10 keV) X-ray luminosity as a proxy for the AGN power, to select a sample spanning AGN from the lowest activity (e.g., LINERs) to the highest activity (e.g. quasars). The sample includes about 100 AGN, and covers more than six decades in 2–10 keV X-ray luminosity ($\sim 3\times10^{38}$ to $\sim 3\times10^{45}$ erg s^{-1}). To construct the full sample, we balanced the X-ray bins in: (1) X-ray luminosity, and (2) AGN type: RL/RQ, Type1/2, LINER, with/without star formation (SF). We will observe the galaxies with the imaging mode using two filters, namely the Si-2 ($\lambda_c = 8.7$ μm) filter and the Q4 filter ($\lambda_c = 20.5$ μm), and with the low-resolution spectroscopic mode covering the ∼8–13 μm spectral range.

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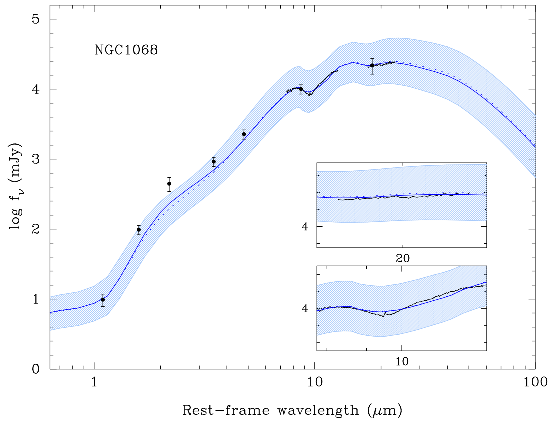

Fig. 1. An example of the fit to the nuclear near-infrared and MIR photometric points, and MIR spectroscopy of NGC 1068 using the Nenkova et al. (2008) clumpy torus models. The insets show in detail the spectral regions around the 10 μm and 18 μm silicate features. Figure adapted from Alonso-Herrero et al. (2011).

In addition we will obtain polarimetric observations for a few of the brightest AGN in our sample.

3. GOALS OF THE SURVEY

We describe here some of the main goals of our survey and discuss some scientific results obtained with similar instruments on other 8–10 m class telescopes, albeit for much smaller samples. These should serve as illustrations of the potential of our CanariCam survey.

3.1. *Unification of Type 1 and Type 2 AGN*

There has been claims in the literature of a luminosity dependence of the Type1/Type2 ratio of AGN, with the fraction of Type 1 objects increasing for higher luminosities (Simpson 2005). The physical origin of this relation is unclear, and several authors proposed a change in the geometry of the obscuring material around AGN. Through the comparison of the MIR imaging and spectroscopic CanariCam observations and models, spanning a wide AGN luminosity range, we will check whether the decrease of obscuration as a function of luminosity is due to a change of the distribution of the clouds, or of their number, or of their individual optical thickness.

Figure 1 shows an example of the successful application of the Nenkova et al. (2008) clumpy torus models to fit the nuclear infrared emission, including MIR spectroscopy, of NGC 1068. The MIR data have obtained with other 8–10 m class telescopes with similar instrumentation (see Alonso-Herrero et al. 2011, for full details). This kind of model fitting is particularly useful not only to estimate the torus model parameters, but also to recover the intrinsic AGN luminosity. Our recent work with small samples seems to indicate some dependency of the torus geometry on the Type1/Type2 class (Ramos Almeida et al. 2011) and/or luminosity of the AGN (Alonso-Herrero et al. 2011). We will perform a similar modelling for a more statistically significant sample of AGN using the CanariCam and complementary observations.

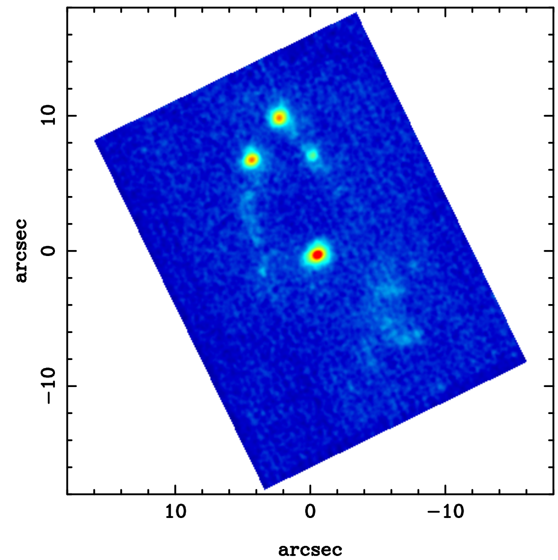

Fig. 2. Gemini/T-ReCS Qa-band (λ_c = 18.3 μm) image of the central region of the Seyfert 1.8 galaxy NGC 1365. Adapted from Alonso-Herrero et al. (2012).

3.2. *Star formation activity around AGN*

Since material must be driven inwards from the ISM of the host galaxy to the nucleus (<10 pc regions) to fuel the AGN, nuclear SF appears to be an inevitable consequence of this process. Although there is evidence of the presence of SF in AGN, especially in Type 2s, there are also a number of caveats. Classical SF indicators (UV, Hα, near-IR emission lines) are difficult to use in Type 1 AGN, as they can be easily contaminated by bright AGN emission. It is then not clear if there is increased SF activity in the hosts of Type 2 AGN (Maiolino & Rieke 1995) and whether the SF level depends on the activity class (e.g., radio galaxy, QSO, see Shi et al. 2007) and/or AGN luminosity and Type. The limited angular resolution of most of the previous work only probed regions on kpc scales but with CanariCam we will be able to resolve smaller physical scales.

We will use the spatially-resolved CanariCam observations to trace the SF activity around AGN, in particular the extent and strength of nuclear and cir-

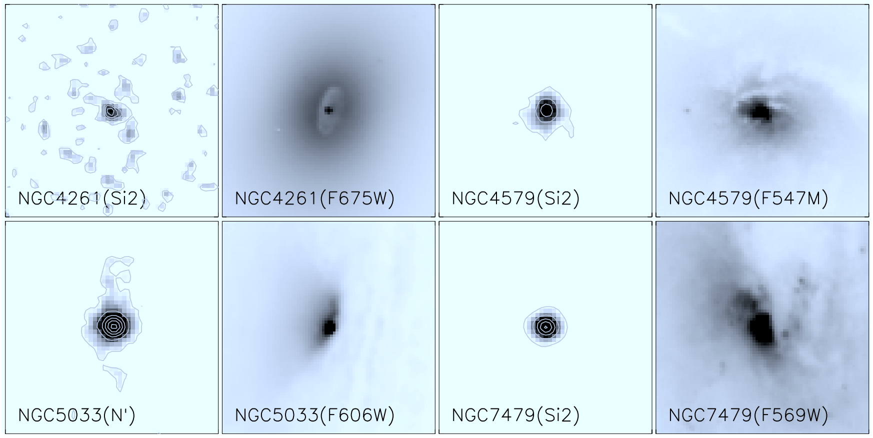

Fig. 3. Comparison between Gemini/T-ReCS or Michelle MIR (N' and Si-2 filters) and HST optical (F547M, F569W, F606W, F675W filters) morphologies of the central regions of 4 LLAGN. Figure adapted from Mason et al. (2012).

cumnuclear star-forming regions in AGN. We have already used Gemini/T-ReCS imaging and spectroscopy to study the spatial distribution of the nuclear and circumnuclear activity of a small number of galaxies hosting a Seyfert nuclei (Alonso-Herrero et al. 2006; Díaz-Santos et al. 2008, 2010). In Figure 2 we show a Gemini/T-ReCS 18.3 μm image of the nearby ($d = 18.6$ Mpc) Seyfert 1.8 galaxy NGC 1365. In the case of this galaxy, there is some extended MIR emission around the AGN (inner $\sim$40 pc), but most of the (obscured) SF activity in the central regions, as probed by the 18.3 μm emission, is in a $\sim$2 kpc-diameter ring (see Alonso-Herrero et al. 2012).

3.3. *LLAGN and the origin of the torus*

LINERs are detected in the nuclei of about 50% of nearby spirals and ellipticals (Ho 2008), and there is an on-going debate on whether they are powered by low-luminosity AGN (LLAGN) and/or SF. The detection of broad Hα components means that at least, some LINERs do contain an AGN. On the other hand, the possible lack of tori is predicted by the disk wind model which states that the torus originates as an accretion disk wind. Fortunately, this model makes a testable prediction: below $L_{\rm bol} \sim 10^{42}$ erg s^{-1} mass accretion can no longer sustain the outflow required for large obscuring columns (Elitzur & Shlosman 2006). Moreover, how the properties of LLAGN tori, if they exist, might relate to those in higher luminosity AGN is completely open to question.

We will use the CanariCam data to search for thermal dust emission from the AGN torus. In our recent work using the MIR instruments on the Gemini telescopes we have found a variety of MIR morphologies in a sample of LLAGN (Mason et al. 2012). Sources with higher Eddington ratios tend to show more compact and bright MIR sources (see a few examples in Figure 3), whereas LLAGN with low Eddington ratios appear more diffuse and extended in the MIR. It is indeed in the former type of objects in which the torus is expected to be detectable in our CanariCam survey. This is because mechanisms (i.e., synchrotron emission, nuclear SF) other than the dusty torus may contribute significantly to the nuclear MIR emission of LLAGN.

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