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The origin of the IR emission of low-luminosity AGN

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Abstract. To test recent suggestions that the infrared emission of low-luminosity AGN arises in a truncated thin accretion disk, we compare recent, high-resolution IR data with published SED model fits that include emission from the truncated disk. We also fit the data with clumpy torus and optically thin dust shell models. These comparisons suggest that dust can better account for the IR emission of the objects in question than can the truncated disk. That optically thin models give a good fit to the data may support a scenario in which the torus of the AGN unified model does not persist in low accretion rate AGN.

Keywords. galaxies: active, infrared: galaxies.

1. Introduction

Active galaxies spend most of their lives in a low-luminosity, weakly accreting state, in which the accretion process is thought to differ greatly from that of luminous AGN such as quasars. An advection-dominated accretion flow (ADAF) is expected to replace the inner part of the thin accretion disk, and material is channeled into jets and outflows. As the thin accretion disk is truncated relative to that in higher-luminosity AGN, the "big blue bump" should shift to longer wavelengths, perhaps accounting for the red peak observed in the SEDs of some low-luminosity AGN (LLAGN; Ho 2008; Taam *et al.* 2012). Furthermore, a similar relationship between the disk truncation radius and Eddington ratio relation has been proposed for LLAGN and Galactic black hole X-ray binaries, suggesting similar accretion behaviour in both classes of object (Yuan & Narayan 2004). We have therefore taken advantage of recent, high-resolution IR photometry of nearby LLAGN to test whether their IR emission indeed originates in the truncated accretion disk of the ADAF-disk-jet paradigm.

2. The origin of the IR emission

In Figure 1 we show a comparison of a published ADAF+disk+jet model (Nemmen *et al.* 2013) with the *nuclear* spectral energy distribution (SED) of NGC 3031 (Mason *et al.* 2012 and references therein). The original model fit did not include the new IR data. In contrast to most of the other objects in this study, the truncated disk is luminous enough to account for the mid-IR emission of NGC 3031. Its spectral shape, however, is much narrower than the broad, overall IR peak in the data. The ADAF SED has a complex structure with several peaks arising from synchrotron and Bremsstrahlung

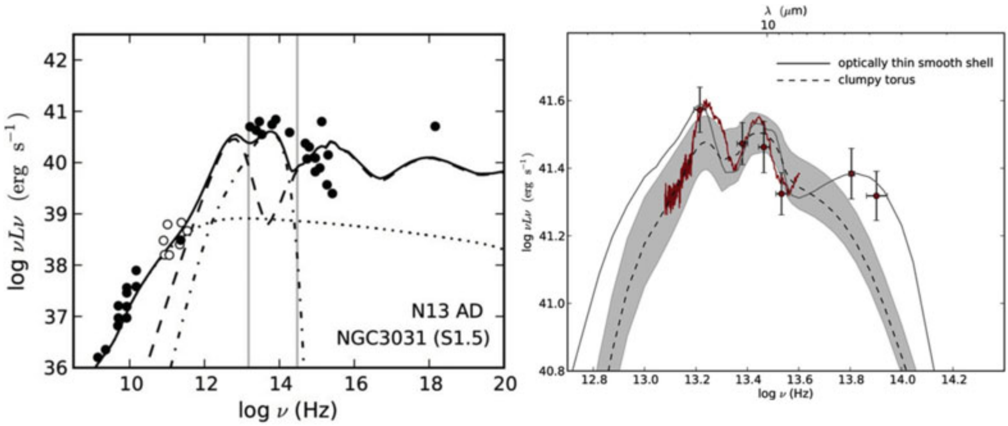

Figure 1. Left: ADAF (dashed) + truncated disk (dot-dashed) + jet (dotted) model fit to the SED of NGC 3031. The truncated disk component is too narrow to account for the broad IR peak in the data (between the vertical lines at 1 and 20 μm). Right: clumpy torus and optically thin smooth shell model fits to the IR SED of NGC 3998. The models provide a reasonable match to the photometry and Spitzer spectrum (red points/line).

radiation and inverse Compton scattering, but their dependence on black hole mass, accretion rate etc. means that none of these is likely to produce the observed mid-IR emission. The jet may contribute the majority of the IR emission in very radio loud nuclei such as M87. The strong silicate emission features observed in many LLAGN, though, argue that dust must also be present (Mason *et al.* 2012).

To investigate the role of dust, we fit the IR SED of NGC 3998 with clumpy torus (Nenkova *et al.* 2008; Asensio Ramos & Ramos Almeida 2009) and optically thin spherical shell (Ivezic & Elitzur 1999) dust models (Figure 1). The clumpy torus model fit implies a bolometric luminosity consistent with that estimated from X-ray observations, and a photon escape probability consistent with the direct view of the broad lines in this object. The model is under-luminous in the near-IR, but this may be due to a (highly uncertain) contribution from the ADAF at these wavelengths, not included in the dust models. The optically thin model is also able to fit the observed SED and silicate features, and may support the hypothesis that the torus begins to disappear in LLAGN (Elitzur & Shlosman 2006). For full details of this work, see Mason *et al.* (2013).

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