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The starburst – active galactic nuclei connection on nuclear scales in near by Seyfert galaxies

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Abstract. Several works have shown that there is an empirical correlation between the star formation rate and the luminosity of the active galactic nucleus (and thus the black hole accretion rate, $\dot{M}_{\rm BH}$) of Seyfert galaxies. This suggests a physical relation between the gas forming stars on kpc scales and the gas on sub-pc scales that is feeding the black hole. Simulations predict this relation and also that the correlation should be more prominent on smaller physical scales. We have compiled high angular resolution (0.4–0.8″) mid-infrared spectroscopy obtained with T-ReCS, VISIR, and Michelle of 29 Seyferts. We use the 11.3 μm PAH feature to probe the star formation activity in the inner ∼65 pc, and its relation with the $\dot{M}_{\rm BH}$ on these physical scales.

Keywords. galaxies: nuclei — galaxies: Seyfert — infrared: galaxies

1. Introduction

The connection between star formation (SF) activity on different physical scales in a galaxy and the presence of an active galactic nucleus (AGN) has been a long discussed topic. There still are many uncertainties under consideration to disentangle the processes behind such a relation (see e.g. Hopkins & Quataert 2010). Diamond-Stanic & Rieke (2012) recently found a strong correlation between the kpc-scale SF rate (SFR) derived using the 11.3 μm PAH feature and 24 μm observations and the black hole accretion rate ($\dot{M}_{\rm BH}$) for Seyfert galaxies. However, the limited angular resolution of their *Spitzer* data ($\sim 4-5''$) did not allow them to resolve nuclear scales, and it is unclear if the measured PAH feature was associated with the galaxy or the nuclear environment.

In this work we present the largest compilation to date of high angular resolution ($0.4 - 0.8''$) mid-infrared (MIR) spectroscopy of Seyfert galaxies. This enables us to study the SFR-$\dot{M}_{\rm BH}$ relation at different scales in the local Universe.

2. The sample

The sample used in this work consists of ground-based N-band (∼8–13 μm) spectroscopic observations of 29 Seyfert galaxies (13 Type 1, 16 Type 2) belonging to the RSA galaxy catalogue (Sandage & Tammann 1987). These were taken with three different instruments operating on 8m-class telescopes, the Thermal-Region Camera Spectrograph (T-ReCS – Gemini-South), Michelle (Gemini-North) and the VLT spectrometer and imager for the MIR (VISIR – VLT). For the distances of our sample, the ground-based slit widths probe typical physical scales of ∼65 pc (median value). We also use MIR spectra taken with IRS on board *Spitzer* to investigate the extended ($\sim$ 600 pc) SF in

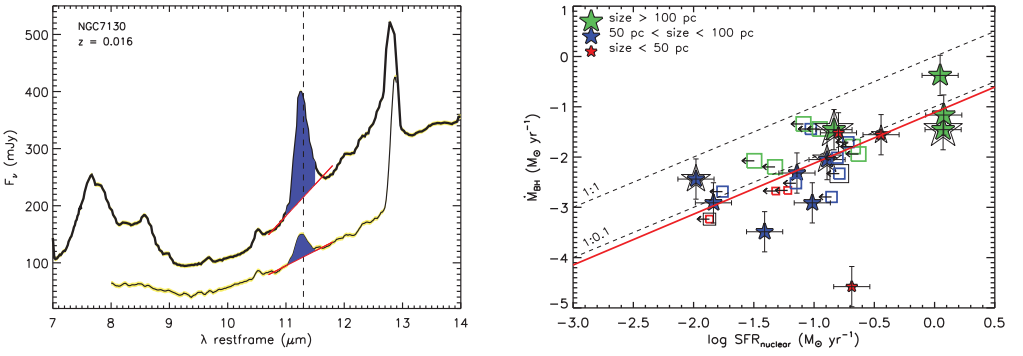

Figure 1. Left panel: spectra of NGC 7130 (T-ReCS: thin line; IRS: thick line). Right panel: observed nuclear SFR vs. $\dot{M}_{\rm BH}$ relation (star: detection; square: upper limit). The solid line represents the fit to our detections of the nuclear 11.3 μm PAH feature (slope of 1.01 ± 0.4).

the host galaxy (see Fig. 1, left panel for an example). We used the polycyclic aromatic hydrocarbons (PAH) feature at 11.3 μm to study the nuclear SF activity (e.g. Roche *et al.* 1991) and its relation to the circumnuclear SF, as well as with $\dot{M}_{\rm BH}$. We used the hard 2−10 keV X-ray luminosity as a proxy for the AGN bolometric luminosities after correcting for absorption and applying the bolometric corrections of Marconi *et al.* (2004).

3. Results

The main results can be summarized as follows (see Esquej *et al.* 2013, for full details):

(*a*) There is no evidence of strong suppression of the nuclear 11.3 μm PAH feature in the vicinity of these AGN. The clumpy torus would be responsible for shielding the PAH molecules from AGN X-ray photons.

(*b*) The detection rate of the nuclear 11.3 μm PAH feature in our sample of Seyferts is 45 % (13 out of 29 sources), at a significance of 2σ or higher.

(*c*) The derived nuclear SFRs are between 0.01 and 1.2 $M_{\odot}\,{\rm yr}^{-1}$. This is, on average, five times lower than those in circumnuclear regions. The projected nuclear SFR densities are a factor of 20 higher than those measured on circumnuclear scales. This indicates that the SF activity is highly concentrated in the nuclear regions in our sample.

(*d*) Predictions from numerical simulations for the appropriate physical regions are broadly consistent with the observed relation between the nuclear SFR and $\dot{M}_{\rm BH}$ in our sample (see Fig. 1, right panel).

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