Looking for signs of supermassive black hole growth in ultra-compact UV-luminous galaxies using mid-infrared spectroscopy

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1. Abstract

The formation of supermassive black holes (**SMBHs**) and their co-evolution with the host galaxy is poorly understood in the early Universe. How is the growth of the stellar bulge related to the growth of the SMBH? To answer this, it is critical to look at the coexistence of star formation activity and SMBHs.

To tackle this, we use the mid-infrared (**IR**) spectra of 25 LBAs. We use the mid-IR slope and the prominence of polycyclic aromatic hydrocarbons (**PAHs**) emission features to quantify the contribution of the underlying power sources and identify signs of SMBHs.

2. Using nearby galaxies to study black hole seeds

Lyman Break Galaxies (**LBGs**), typical star-forming galaxies in the early (z > 2) Universe are believed to be one of the precursors of present-day galaxies. They may provide a great laboratory to investigate the relationship between star formation and SMBHs. Unfortunately, at high redshifts, it is hard to study galaxies as their distance renders them small and faint.

There are galaxies at intermediate redshifts that share the properties of those at higher redshifts and can work as proxies for detailed studies.

Such is the case of Lyman Break Analogs (**LBAs**), local ultra-compact UV-luminous galaxies analogous to LBGs.

Some LBAs contain a dominant central object (**DCO**), which appears to be an ideal seed for an obscured SMBH (Ovezier et al., 2009). The majority of these LBAs are optically classified as a composite of starbursts and active galactic nuclei (**AGNs**) — a growing SMBH (Jia et al., 2011). The optical spectra alone cannot establish the presence of an AGN unambiguously. The mid-infrared offers a way to eradicate this ambiguity.

3. Where and how

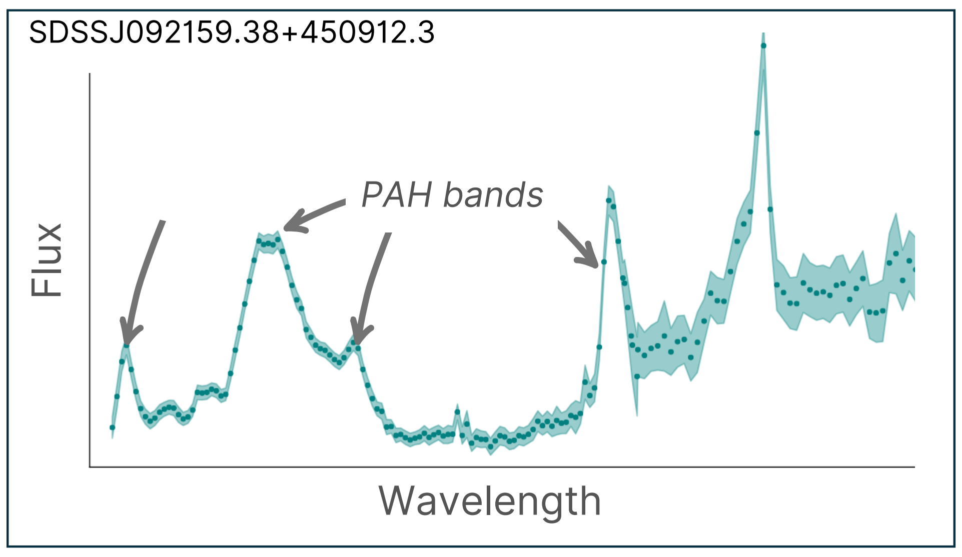
Sample and data

Our sample of 25 galaxies at 0.1<z<0.3 (median = 0.19) is a sub-sample of those observed by the Galaxy Evolution Explorer (**GALEX**) telescope and classified as LBAs (Heckman et al. 2005a; Hoopes et al. 2007).

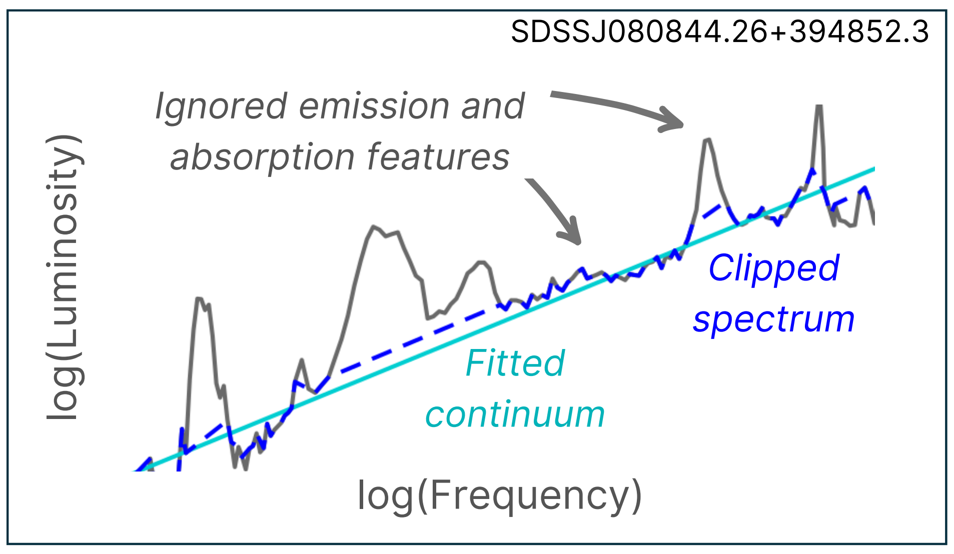
We use the mid-IR spectra observed with the Spitzer Space Telescope Infrared Spectrograph (**IRS**). Our focus is in the 5–15μm region, where the PAH bands are present. These bands encode plenty of information about the underlying energetics of the medium these molecules are in.

PAH contribution

To quantify the prominence of PAHs, we use the equivalent widths (**EWs**) obtained with the PAHFIT routine (Smith et al., 2007).



Above is the spectrum of a LBA with prominent PAH features and an underlying significant dust continuum potentially associated with an AGN.



Mid-infrared slope

To find traces of AGN presence, we evaluate the steepness of the mid-IR continuum in the log-log plane. High values of inclination are associated with starburst activity or obscured AGNs. To get the slope, we clip the emission and absorption features and fit a line (Menéndez-Delmestre et al., 2009).

4. Our findings and concusions

We found steep continua in all LBAs, indicative of the presence of warm dust emission associated with the presence of star formation or heavily obscured AGNs. On the other hand, we found small values of EWs for the PAH bands. This result has been associate with the presence of a dust-obscured AGN (Díaz-Santos et al., 2017).

These results hint at evidences that the DCOs are, in fact, black hole seeds. This is a work in progress that will be furthered by spatially-resolved analysis that can detangle the emission of the DCOs from the starbursts found in the LBAs. This type of analysis will be systematic in the mid-IR with the upcoming launch of the James Webb Space Telescope (**JWST**) thanks to its Mid-Infrared Instrument (**JWST/MIRI**).

Acknowledgments

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