Supermassive Black Holes in Dwarf galaxies at the peak of Cosmic Star Formation History

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Introduction

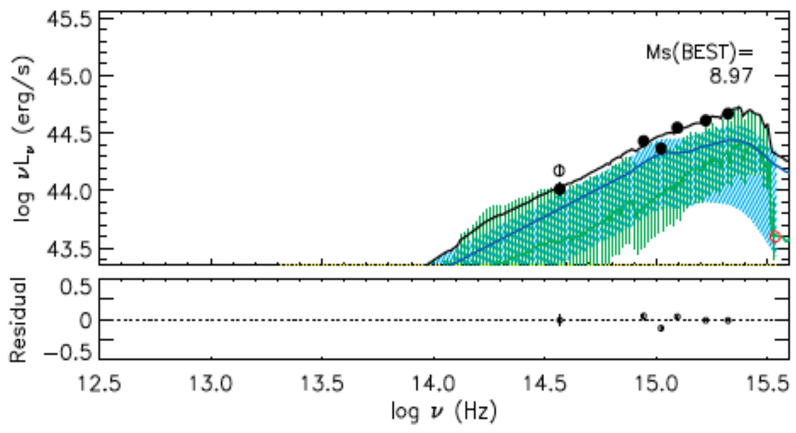
Supermassive black holes are thought to originate from seed black holes of $M_{BH}=10^{3-6}$ $M_\odot$ formed in the early universe and grown through cosmic time. Seed black holes are expected to form at z>10 via direct collapse of primordial gas, mergers in dense stellar clusters, or the death of the first generation of Population III stars, among other possibilities. Such seeds could be powering active galactic nuclei (AGN) in dwarf galaxies, tens of which have been found today. However, providing any connection between the early seeds and local supermassive black holes has so far not been observationally possible.

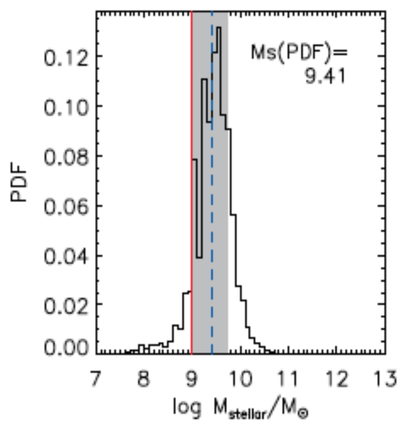
AGN hosting Dwarf galaxy Sample

- A Parent sample of 1161 broad-line AGNs in the VIPERS survey
- Having an LMC-like stellar mass $M_{stellar}< 9.5$ $M_\odot$
- Final sample consists of 22 broad-line AGN dwarf galaxies
- A spectroscopic redshift ranging from z=0.35-2.77
- They are all star-forming galaxies (sit above the main sequence of star formation)

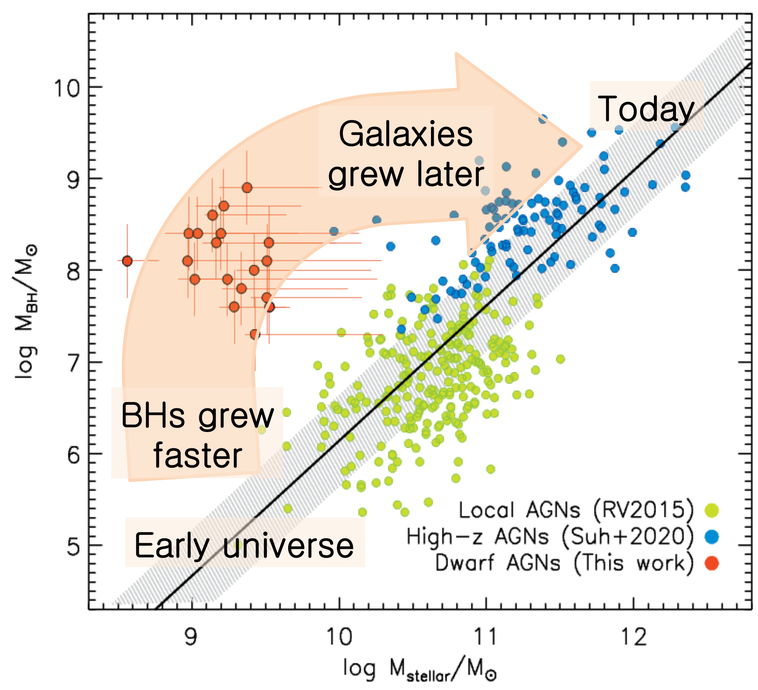
Stellar masses – SED fitting

- Multiwavelength photometry from GALEX (FIR, NIR), CFHT (u, g, r, i, z, ks), VISTA K, Spitzer/IRAC (3.6, 4.5, 5.8, 8.0um), Spitzer/MIPS 24um, WISE (3.4, 4.6, 12.1, 22.5um)
- Multi-component SED modeling to disentangle the galaxy lights from the AGN (Suh+2019)
- Since the AGN and galaxy lights are highly degenerated, we derived a probability distribution function (PDF), considering any possible combination of SED parameter space and AGN fraction (f_{AGN}= 0 to 1).
- To obtain an upper limit on the stellar mass, we assume galaxy light dominates over the AGN (f_{AGN}=0), providing a conservative upper limit on the stellar mass.
- We also perform the SED fitting using CIGALE (Boquien+2019), finding that the stellar masses are consistent with our results.





M_{BH} vs $M_{stellar}$ of AGN host dwarf galaxies



- We compare the location of AGN hosting dwarf galaxies on a M_{BH}-M_s diagram to that of local and high-z AGNs.
- AGN host dwarf galaxies are more massive than expected from the local + high-z AGN relation.
- The presence of outliers has been found in massive galaxies and can be explained if the black holes have grown more efficiently than their host galaxies, contrarily to models of synchronized growth.
- Based on semi-analytical simulations, AGN in dwarf galaxies are most likely seed black holes formed via direct collapse of primordial gas and that grew faster than their host galaxies.
- The AGN host dwarf galaxies are expected to evolve into massive systems by z~0, indicating that local active supermassive black holes in massive galaxies can originate in dwarf galaxies hosting seed black holes at higher-z.

Black hole masses – Emission line fitting

- We fit the spectra using a multi-component spectral fitting code, Python QSO fitting (PyQSOFit)
- Single-epoch virial black hole masses are derived from the Hα, Hβ, MgII, and CIV broad-line width and continuum/line luminosity depending on the redshift.
- The uncertainties are computed using a Monte-Carlo estimation.
- Log M_{BH}=7.3-8.9 $M_\odot$ with an uncertainty of ~0.4 dex
- Mostly accreting at sub-Eddington ratios (~0.2)