Correlations between SMBH Mass and Sérsic Index of AGN Host Galaxies
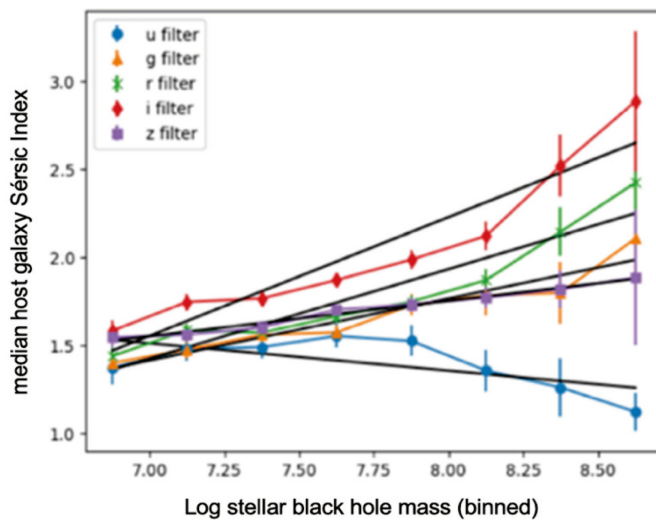
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Abstract: The purpose of this study was to find the correlation between the mass and Sérsic Index of 10,000 active galactic nuclei (AGNs) taken from the low-redshift low-luminosity AGN characterized by Chanchaiworawit & Sarajedini (2024) [2]. The result of this study revealed that there are strong positive correlations at z < 0.4. This is likely due to an increase in younger, less morphologically developed galaxies at higher redshifts. Another result is a strong correlation between the Sérsic Index and redshift, which can support the hypothesis that AGN host galaxies are transitioning into a quiescent stage.

Introduction and Method: Correlations between supermassive black hole (SMBH) mass and the Sérsic Index of active galactic nuclei (AGNs) host galaxies' bulges are well established [4]. Here, I try to see whether black hole mass-Sérsic Index relations can also be found for the entire host galaxy.

The luminosity at 5100 Angstroms and the width of the H-beta broad component in AGN spectra can be used to calculate the mass of the SMBH in solar masses, as defined by Park et al (2015) [3]. R90 is the radius of a circle which contains 90% of a galaxy's luminosity, and R50 is the radius of a circle which contains 50% of a galaxy's luminosity. The value of R90/R50 for a certain galaxy is directly correlated to the Sérsic Index. Graham et al (2005) [1] provides the relationship between R90/R50. I calculated the Sérsic Indexes in all SDSS color filters for each AGN using NumPy's interpolation.

Results and Conclusion: I created bins of log black hole mass from 6.5 < x < 9 based on the emission line fitting methods prescribed by Chanchaiworawit & Sarajedini (2024) [2], and plotted the median host galaxy Sérsic Index in each bin, with more than 1000 AGNs in each bin, as demonstrated in Figure 1 and Table 1.

Figure 1: Binned log black hole mass of AGN vs. median host galaxy Sérsic Index, with a bin range of 0.25 dex in log-space for z<0.2. The error bars represent standard error on the mean (SEM).

There are positive trends between the Sérsic Index and black hole mass, but not at higher redshifts, likely due to less morphologically developed galaxies. The 'u' and 'g' filters are also unreliable, likely due to the detection of redshifted X-ray and UV emissions from the AGNs. However, the strong positive trends in the 'r', 'i', and 'z' filters give undeniable evidence of the correlation between the growth of SMBH and the structural evolution of their host galaxies. Higher Sérsic Indexes are present at lower redshifts, similar to the findings of Ormerod et al (2023) [5], in which they find a negative correlation between Sérsic Index and redshift for quiescent galaxies. This confirms the common hypothesis that AGN host galaxies are in a transition between their star-forming and quiescent stages.

Table 1: Best fitted slopes and their uncertainties of binned log black hole mass of AGN vs. median host galaxy Sérsic Index, rounded to 3 decimal points.

	U band	G band	R band	I band	Z band
Z < 0.2	-0.155 +/- 0.075	0.352 +/- 0.044	0.508 +/- 0.073	0.674 +/- 0.099	0.200 +/- 0.012
0.2 < z < 0.4	0.068 +/- 0.065	0.022 +/- 0.022	0.161 +/- 0.021	0.072 +/- 0.026	0.137 +/- 0.026
0.4 < z < 0.6	0.418 +/- 0.074	0.076 +/- 0.029	0.052 +/- 0.028	0.006 +/- 0.042	-0.052 +/-0.079

References

[1] Graham, A.W., Driver, S.P., Petrosian, V., et al. 2005, ApJ, 130, 1535
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