Using SED Model Fitting to Search for Star-Forming Galaxies at z>4.5

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Astronomy 25 Term Project

1. Abstract

Supermassive black holes (SMBH) were formed from Pop. III stellar remnants or direct-collapse black holes accreting material over time. We should see significant black hole growth in the redshift range z=5-10. The results of Cowie et al. (2020), however, show a sharp drop in number density of accreting SMBHs in the form of accreting galactic nuclei (AGNs) from about 3<z<6 (Fig. 1). They find only 11 AGN at z>4.5. To expand upon this study, I investigated the final candidate set of AGN in Cowie et al. (2020), to see if some of the AGN galaxies found might be star-forming galaxies at lower redshift. I conclude that at least one of the 10 objects in the group is likely a star forming galaxy based on its SED shape, justifying a deeper look at the matter.

2. Summary of Paper

Cowie et al. (2020) works to identify possible AGN candidates and determine their redshifts, looking for high-redshift (z>5) candidates. Using directly-observed X-ray sources, and pre-selecting candidates from other wavelengths, including ALMA and NIR/MIR CANDLES data in the Chandra Deep Field South (CDF-S). Photometric redshift estimates of AGN candidates were tested with FIR/submillimeter SEDs. The primary result was that the number-density of AGN sources drops dramatically from redshift 3<z<6. Indicating very little black hole accretion.

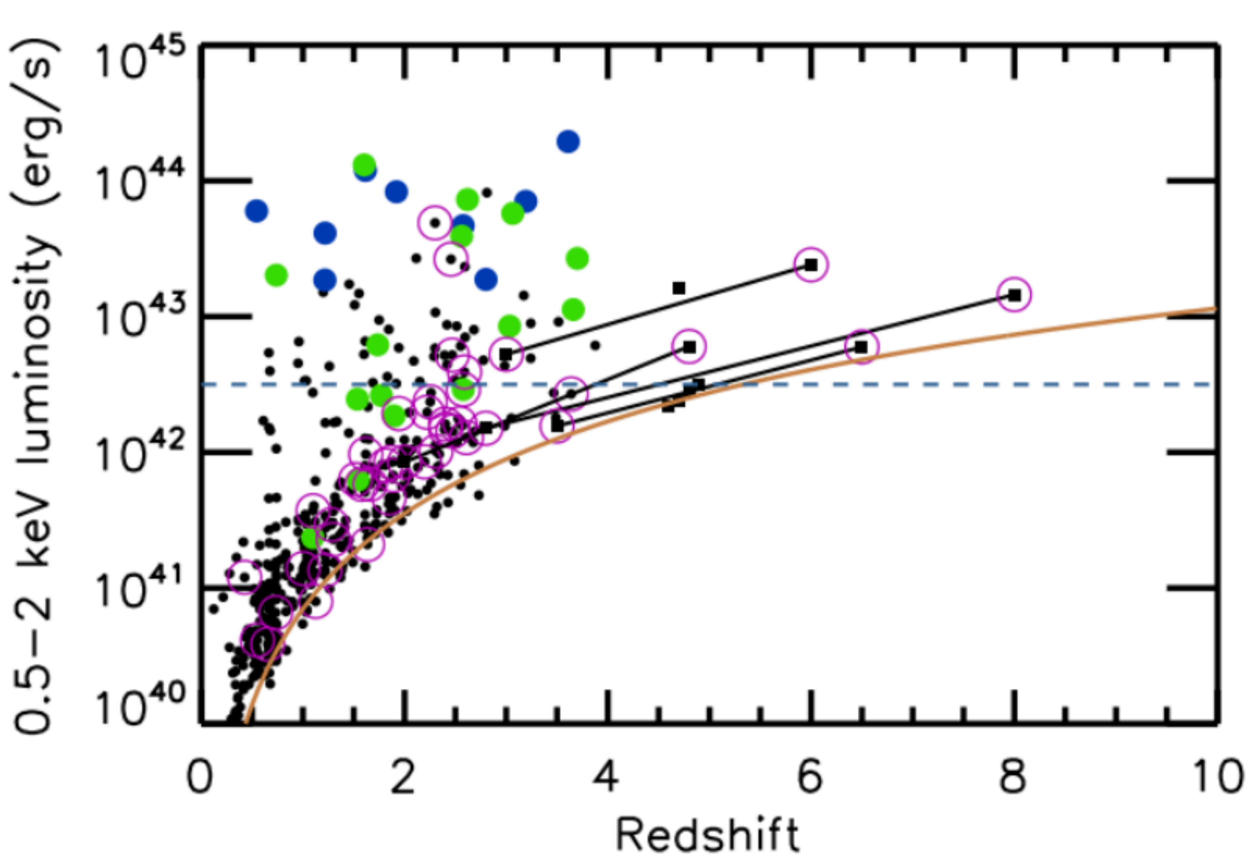

Figure 1: Luminosity vs. Redshift for final AGN candidates. Blue dots are known broad-line AGNs, green dots are Seyfert type-2 galaxies. Purple circles are ALMA sources, connected by a black line in the case of sources with ambiguous redshifts. The number density drop off from 3<z<6 is noticeable.

3. Procedure

As part of identifying good pre-selection candidates from ALMA, Cowie et al (2020) created Spectral Energy Distribution (SED) models for several potential candidates. The SED of a star forming galaxy and an AGN will have different shapes. Using MAGPHYS, an SED-fitting program, which takes in the photometric SED data for 15 different filters (ranging from .1-10 microns) from the CANDELS catalogue (Guo et al. 2013), I generated SEDs for the 10 final candidates with available SED data. I compared their shapes to known SEDs for different types of galaxies from Polleta et al. (2007) (Fig. 3), to get a sense of whether they may be star-forming galaxies.

References

Cowie et al. 2020, ApJ (accepted for publication)
Guo et al. 2013, ApJS, 207, 24
Polleta et al. 2007, ApJ, 663, 81-102

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4. Results

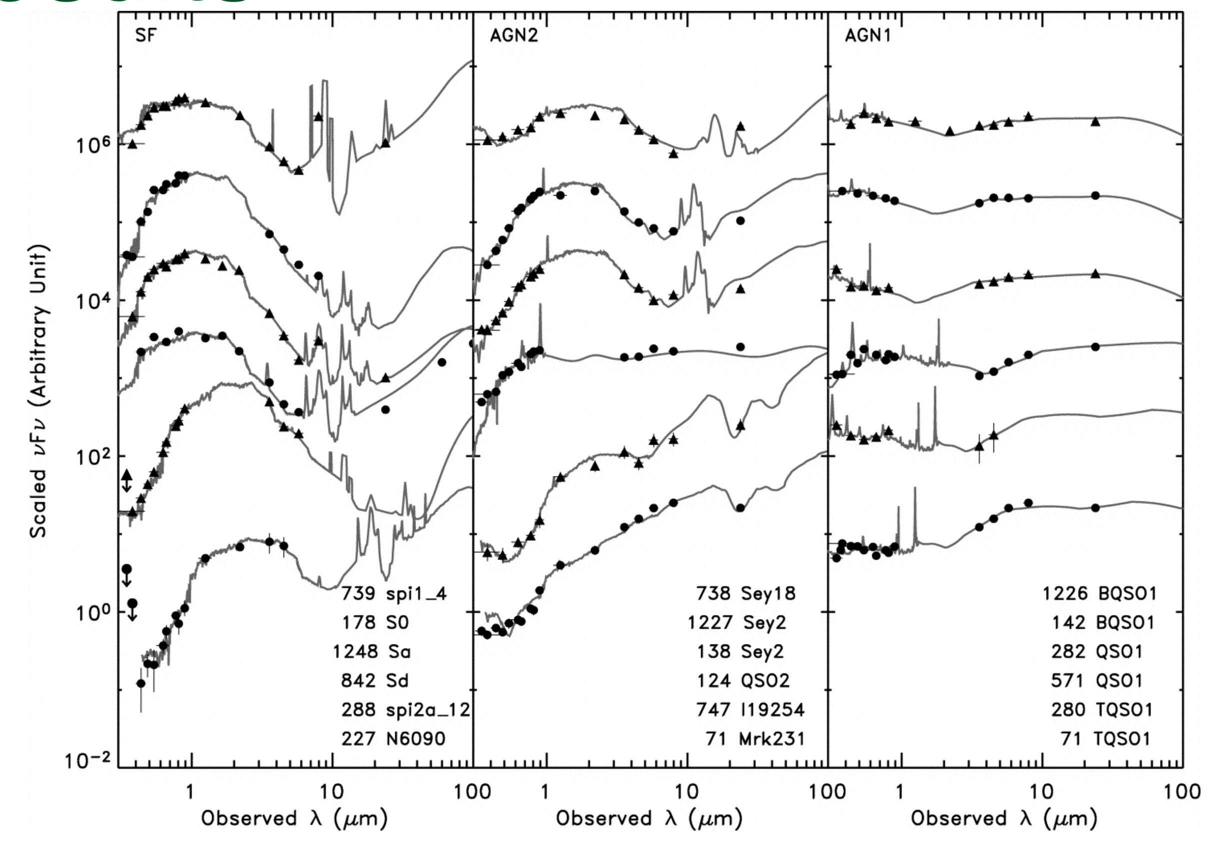

Figure 2: Example SEDs from Polleta. Star forming galaxies are in the left column, while the middle and right columns have different types of AGNs. These SEDs are used to compare the model SED shapes in order to gain insight into what sort of galaxy is observed.

I grouped the 10 candidate objects into three broad categories. The first being galaxies that are probably star-forming. Object 3 (Fig. 3, top right) from Cowie was the only one solidly in this group. Its SED looked the most like the star-forming SEDs from Polleta (Fig. 2), with a greater luminosity at shorter wavelengths. Galaxy 3 also had a relatively low x^2 value (x^2= 0.535), meaning the fit was good to a star-forming model. The second group is galaxies that are probably AGNs. These galaxies have SEDs that are generally more constant over wavelength, as they get high-wavelength emission from the accretion disk that is not present in star-forming galaxies. These also tended to have higher x^2 values. This makes sense because MAGPHYS is primarily trained on star-forming SEDs, so AGN SEDs would be expected to have worse fits. Object 10 (x^2= 10.640) in Fig. 3 (bottom) is an example of this category. The final group contained the gray-area galaxies, as their shapes and x^2 values do not easily sort into either of the previous groups.

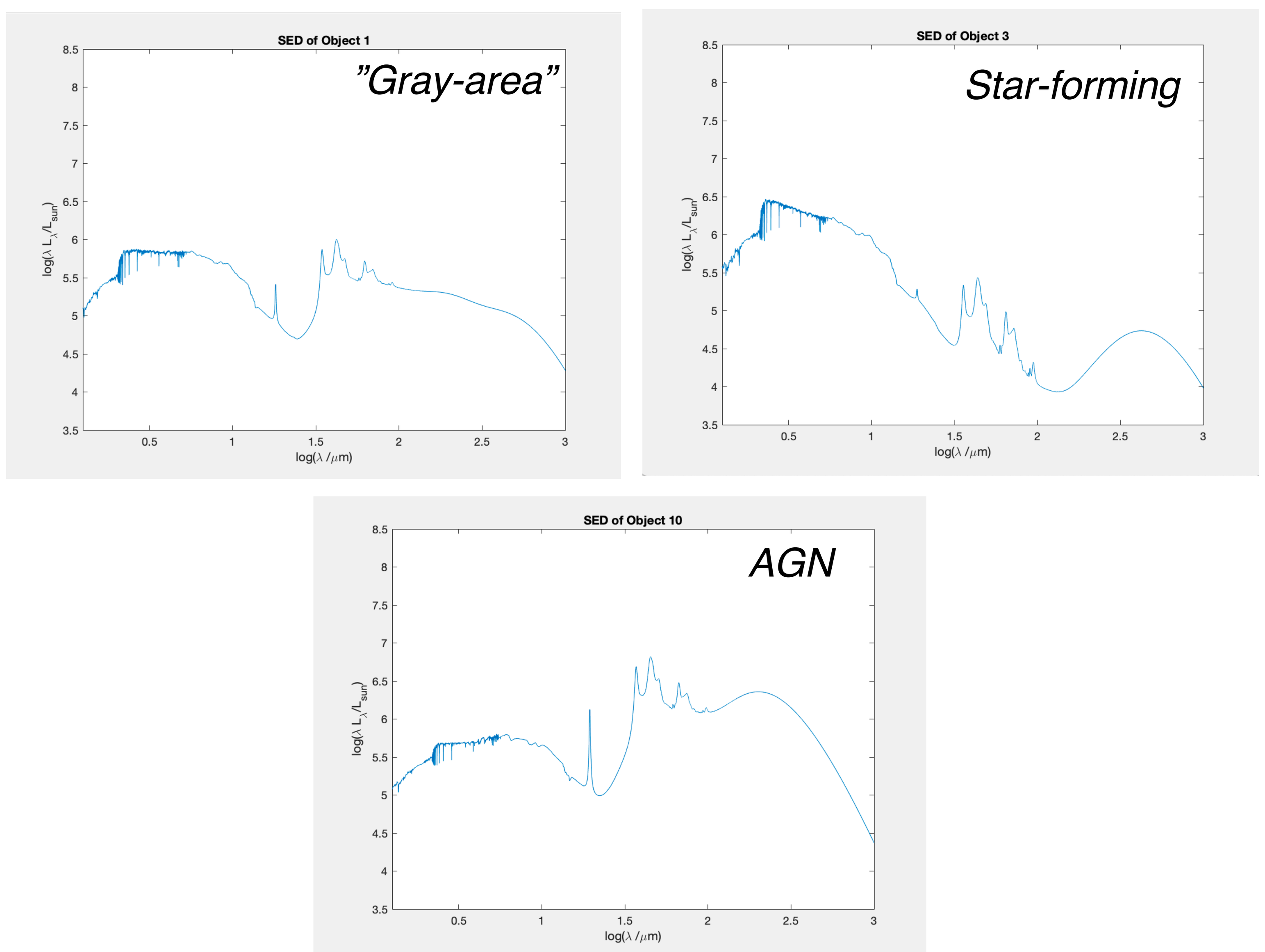

Figure 3: Three representative SEDs for the three broad categories; star-forming (top right) AGN (bottom), and gray-area (top left)

5. Conclusions

I conclude that at least one of the z>4.5 candidates is plausibly not an AGN based on its SED shape and relatively good fit, further confirming the assertion of Cowie et al. (2020) that the AGN number density drops dramatically from z=3-6. In order to further extend this analysis IR spectral observations could be taken to plot these candidates on a BPT diagram. I was unable to do this because the NII and OIII lines needed for a BPT diagram have been redshifted out of the visible spectrum, and I could not find IR spectral data for these sources. This sort of extension would be particularly helpful in analyzing the gray-area source group.