Course: The Physics and Evolution of Active Galactic Nuclei

Reading report 1

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Paper name:

Active Galaxy Nuclei at high redshifts: properties and environment of Type 1 and 2 AGNs

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Paper download link:

http://adsabs.harvard.edu/cgi-bin/bib_query?arXiv:1806.10224

Paper abstract:

We explore host galaxy properties and environment of a sample of Type 1 and 2 active galactic nuclei (AGN) taken from the COSMOS2015 catalog (Laigle et al.), within $0.3 \leq z \leq 1.1$ selected from their emission in X-rays, optical spectra and SED signatures. We find different properties of host galaxies of distinct AGNs: Type 1 reside in blue, star-forming and less massive host galaxies compared to Type 2. The majority of the AGNs have intermediate X-ray luminosities, $10^{42} \leq L_X < 10^{44}$ erg s^{-1}, while only a few have X-ray luminosities ($L_X > 10^{44}$ erg s^{-1}) as those observed in QSOs. Non-parametric morphological analysis show that the majority of Type 1 AGN hosts are elliptical or compact galaxies, while Type 2 AGN host present more scatter, from spirals, irregular, and elliptical galaxies. The environment of the different AGN types are similar except at small scales ($r_p < 100$ kpc), where Type 2 AGNs have more neighbour galaxies than Type 1s. Galaxies located close to Type 2 AGNs (~ 100 kpc) tend to have redder colours, and are more massive compared to the local environment of Type 1s. The observed differences in the environment and host galaxy properties of Type 1 and 2 AGN types show that the obscuration due to the presence of gas and dust may be distributed in larger galactic-scales, possibly originated by galaxy interactions or mergers.

Q1: What is this work all about? What is your overall impression on the quality of this work (poor, average, good, or great)? Explain briefly your assessment. [$\gtrsim$ 100 words required]

This work tries to analyze whether host-galaxy properties are similar for type 1 and type 2 AGNs at relatively high redshifts ($0.3 \leq z \leq 1.1$) in the COSMOS field. The

authors examine the colors, hardness ratio (HR) of X-ray spectra, morphology, stellar mass, and environments.

My overall impression on the work: average. The first reason is that the authors do not consider AGN contamination when analyzing color distributions of AGN host galaxies. They mention the contamination and say that it does not affect their results, but I think their arguments are not convincing. The second reason is that there are not quantitative results most of the time, i.e., they do not calculate errors and significance for many results. Besides, they do not explain some procedures in their paper very clearly.

Q2: Why do the authors carry out this work (including, e.g., current research status, issues, scientific motivations)? [$\gtrsim$ 150 words required]

The coevolution of galaxies and supermassive black holes is becoming increasingly important in recent years. The advantages of such kind of study nowadays are at least two-fold compared to previous studies: higher computing speed enables more careful theoretical studies; wide and deep surveys allows a larger sample back to the earlier universe. Due to these reasons, astronomers have been proposing better models or finding more evidence supporting the scheme instead of the traditional unified model for AGNs. Among all the related issues, one straightforward and vital thing is to compare host-galaxy properties for type 1 and type 2 AGNs. AGN type is one of the most common classifications to distinguish various AGNs. Besides, one of the key predictions of the unified model is also related to AGN type: different types of AGNs are intrinsically the same objects, and thus they have similar host-galaxy properties. However, coevolution scheme assumes that AGN type depends on the evolutionary phase, so host-galaxy properties should be different for the two populations. Given the two contradictory predictions of the two models, astronomers can examine host-galaxy properties to test the two models. Another reason to carry out this work lies on that there is not a consensus regarding the difference of host-galaxy properties for the two populations, and thus a more reliable work is needed.

Q3: How do the authors manage to finish this work (including, e.g., using new data, new techniques, new models)? [$\gtrsim$ 250 words required]

Their studies are based on the COSMOS2015 catalog, which is a relatively new dataset. COSMOS is a large area with an intensive investment of spectroscopic and multi-wavelength observations. Besides, there are many works based on COSMOS releasing valuable catalogs containing many physical parameters (e.g., morphology and environments). Therefore, COSMOS allows astronomers to research from many aspects, just as this work does.

On the whole, this work uses physical parameters available in others' catalogs and utilize statistical methods to check their difference between type 1 and type 2 AGN populations. First, they select a subsample of 202 AGNs from the COSMOS2015 catalog (they do not mention how they select the sample clearly), and ensure that type 1 and type 2 samples have similar redshift distributions. They analyze mid-infrared (MIR) colors (U − [4.5] vs. $L_{4.5}$; [3.6] − [4.5] vs. [5.8] − [8.0]) and rest-frame UV-

optical color (NUV – r vs. r – J; U – B vs. B). They test bimodal distributions based on MIR color distributions. They also divide star-forming galaxies and quiescent galaxies and identify sources in green valley based on UV-optical colors. They use HR to define obscured and unobscured sources and compare fractions of (un)obscured sources in type 1 and type 2 samples. They use a public morphological catalog to study the fraction of each kind of morphology in the two samples. They also examine stellar mass distributions. At last, they check projected radial densities of the populations and their neighbors' properties (color, stellar mass, and star formation rate).

Q4. What are the main results and conclusions of this work? What are the differences/improvements of this work compared to previous relevant works? [$\gtrsim$ 250 words required]

First, host galaxies of type 1 and type 2 AGNs have different color distributions. Type 1 hosts have bluer U – [4.5] and redder [3.6] – [4.5]. Type 1 sources also present possible bimodal distributions regarding the two colors. Based on UV-optical colors, the authors find that all of the type 1 hosts locate in the region of star-forming galaxies in the color-color diagram, while 29% of type 2 hosts distribute throughout the quiescent region and star-forming region, and the quiescent fraction of type 2 sources are unignorable (29%). As for X-ray properties, most of the AGNs have X-ray luminosities similar to those found in Seyfert galaxies ($10^{42} \leq L_X < 10^{44}$ erg s^{-1}), and HRs indicate that type 1 sources are less obscured in X-ray band. As for morphology, type 1 AGNs reside in the region occupied by elliptical or compact galaxies but type 2 AGNs present more scatter. Besides, only 3.8% of the whole sample present signs of mergers. The authors also find that the two populations have similar stellar mass and environment at the scale of $\lesssim$ 0.5 kpc. As the last conclusion, they find that neighboring galaxies of type 1 AGNs are redder and more massive than those of type 2 AGNs, but their star formation rates are similar.

The main improvement of this work is that it is more intensive. The authors construct a more homogeneous and larger AGN sample based on various selections (X-ray, photometry, and optical spectra). Additionally, they analyze lots of aspects of host-galaxy properties, while previous work often focused on only one kind of property.

Q5. What are the main contributions (i.e., scientific significances) of this work? [$\gtrsim$ 100 words required]

The main contribution of this work is that it provides new evidence for evolution sequences and the contribution of gas and dust distributed in larger galactic scales to AGN obscurations. It shows that different types of AGN host galaxies may have different properties such as properties of their neighboring galaxies. Such a difference cannot be entirely explained by the unified model. Besides, the authors manage to extend their study to higher redshifts, allowing a better understanding of a larger cosmic evolutionary range. Indeed, many previous studies focused on low-redshift sources.

Q6. Why can the authors make such contributions (e.g., using new idea, new data, new techniques, new theories)? [$\gtrsim$ 100 words required]

One reason is that they have new data. As mentioned before, COSMOS is covered by many deep spectroscopic and multi-wavelength observations, which enables the detection of lots of AGNs and better constraints on many physical parameters such as stellar mass. The other reason is that many techniques are quite mature now. Astronomers have been researching this field intensively. They released many valuable catalogs containing many physical parameters and proposed many techniques to analyze the parameters. The public COSMOS data and various catalogs enable a careful selection of sources, a large sample and a better comparison of host-galaxy properties based on more physical parameters.

Q7. Can you think of some way to improve this work or to verify it? [$\gtrsim$ 100 words required]

- I think their conclusions based on colors might not be very reliable. It is well known that AGNs may contaminate the observed host-galaxy light, and such an effect is more significant for type 1 AGNs. Therefore, they should take AGN contamination into consideration.
- It would be better if they estimated the errors and gave quantitative significance levels.
- I think their conclusions will be more convincing if they can control other parameters instead of only controlling redshift for type 1 and type 2 sources. After all, other parameters may also cause the difference between the two populations.
- I am confused about why and how they select the sample. I think their sample size is too small to allow compelling conclusions. If possible, a larger sample (e.g., adopting a larger redshift range) may be better.