FORMATION OF AGN IN DUSTY GALAXY:
THE ENVIRONMENT OF LOW REDSHIFT RED QUASARS

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Abstract

Quasar is a class of AGN, and “red quasar” is believed to be in a merging system, which may explain the key procedure of AGN formation. We study the environment – the distribution of neighbor galaxies – of 69 red quasars and 140 normal quasars respectively. Our preliminary results show that neither red quasars nor normal quasars favor the high galaxy density region. And the environments of red and normal quasars are similar, which suggests their close relationship in either evolutionary sequence or their host galaxy properties.

1. Introduction

An active galactic nucleus (AGN) is a relatively active region in a galaxy. There is a black hole in each galaxy. And AGN is the nucleus that the black hole inside is active, which means the accretion rate is high and the radiation from accretion disk is strong.

Quasar is a class of AGN. They are more luminous than other AGNs. Luminous quasars and galaxies coevolve through major merger that triggers both star formation and black hole growth (Glikman et al. 2015). As previous study shows, the dust-reddened quasars in the Near-IR + optical survey are systems in which a **merger-fueled, heavily obscured quasar** is emerging from its shrouded environment (Glikman et al. 2013). Therefore, dust-reddened quasars may represent an intermediate stage between **galaxy mergers** and luminous **blue quasars**, which eventually become quiescent SMBHs (Glikman et al. 2015). We suspect that the dust-reddened quasars (abbreviated to “red quasars” hereafter) are in the merger systems of two supermassive black holes. This fact may tell us the formation of AGN.

Since red quasar is in the merger system, we believe that red quasars are in the environments where the galaxy density is high. Therefore, we study the environments (i.e., the distribution of their neighbor galaxies) of these quasars, including red quasars and normal quasars.

In this report, we first introduce the data, including red and normal quasars and their neighbor galaxies. Second part is the analysis method, focusing on neighbor galaxy density profile and deviation. Third part is the discussion about the possible explanation of these result. Conclusion is in the last part.

2. Data

As mentioned in Introduction, our study object is red quasars. And for comparison, we study also the normal quasars. The environment is the neighbor galaxies of each quasar, so the introduction of galaxy data is in this section.

Red quasars:

Red quasar samples we used are F2M (Glikman et al. 2012) and UKFS (Glikman et al. 2013). Their sky distribution are shown in the Figure 1.

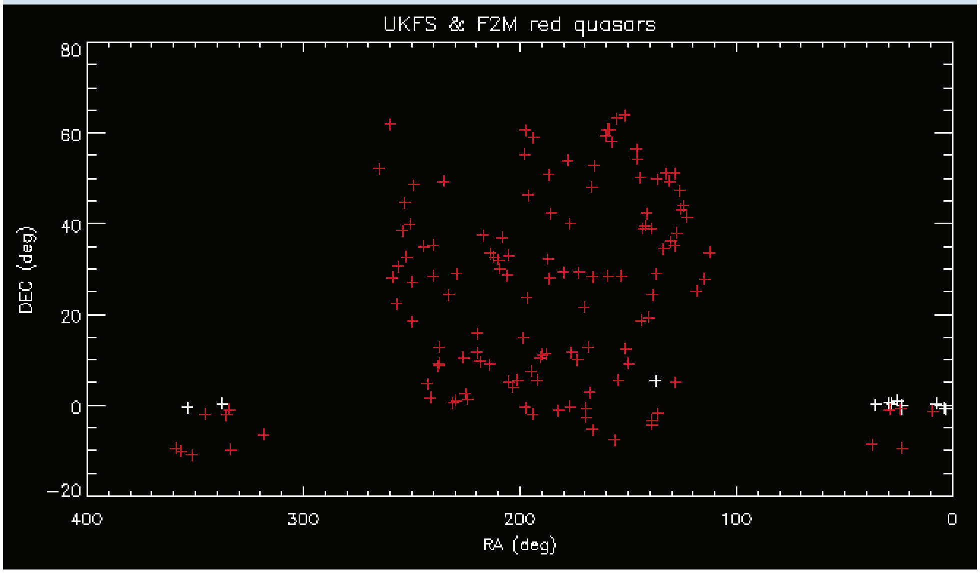


Figure 1. The distribution of red quasars.

Normal quasars:

Normal quasars come from “The Sloan Digital Sky Survey Quasar Catalog: tenth data release”. In order to compare with red quasar samples, we select 169 normal quasars by the constraints – radio observation detected and z less than 0.7 – from this catalog.

Galaxies:

The so called “neighbor” galaxies are defined as below:

1. The redshift of each galaxy is in the range: $z_{QSO} \pm \delta z$, where $\delta z = 0.1$

2. The angular distance on projection plane must be less than the corresponding size of the physical distance 8 Mpc from quasar to each galaxy.

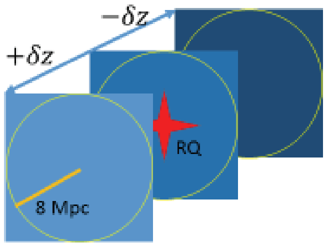


Figure 2. The region of neighbor galaxies

3. Analysis

Our analysis focuses on the environment of each quasar. In order to investigate the environment, we first check the galaxy density profile, which is shown in Figure 3.

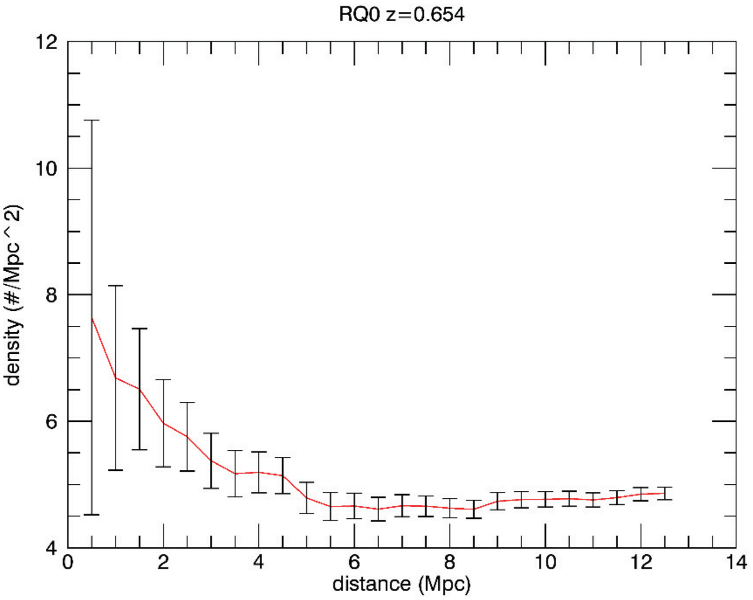


Figure 3. Density profile. X-axis is the distance to the center quasar. Y-axis is the density of galaxies within certain distance (accumulated). Error is estimated by the square root of total count.

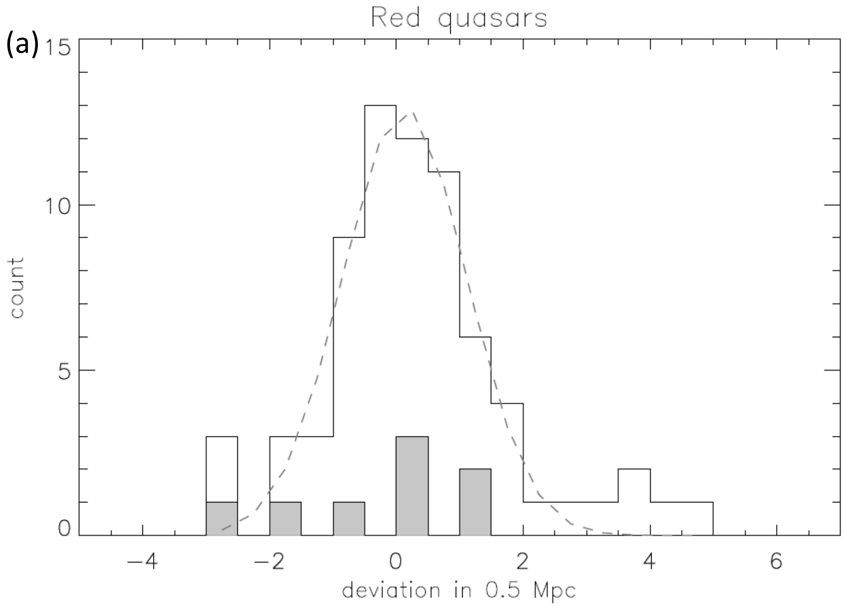
Galaxy number density deviation:

Here, the deviation is the measurement of relative strength of density in certain area to the average background fluctuation. The formula of the galaxy number density deviation:

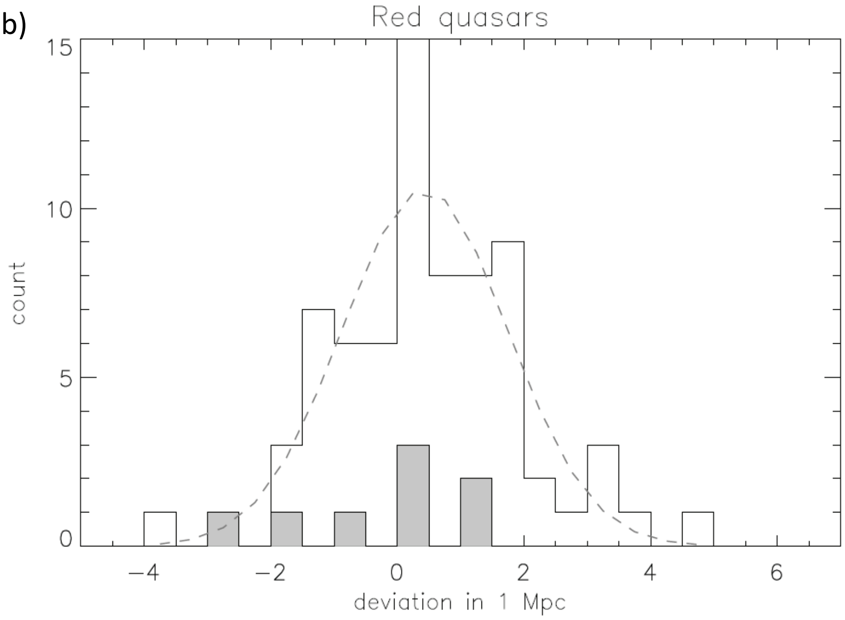
, where and $= \sqrt{C_b}$. The notation, C represents the galaxy count, A is the area in Mpc^2 and σ is standard deviation. The subscript r means the quantity in certain radius, like 0.5 Mpc, 1 Mpc, 2 Mpc, and b represents the background.

The deviation can be simply treated as the density indicator, which means that the magnitude of deviation is high if the galaxy density in central area is higher than the average background fluctuation. And since the denominator of deviation is the sigma of background galaxy count, magnitude of deviation greater than 3 indicates an extreme case.

(a)


Red quasars
count
15
10
5
0
−4
−2
0
2
4
6
deviation in 0.5 Mpc

(b)


Red quasars
count
15
10
5
0
−4
−2
0
2
4
6
deviation in 1 Mpc

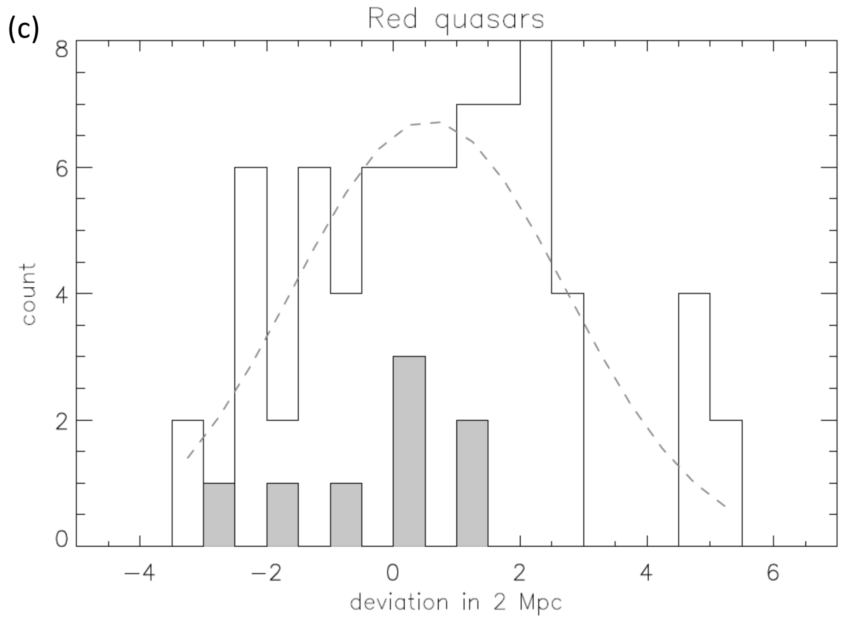
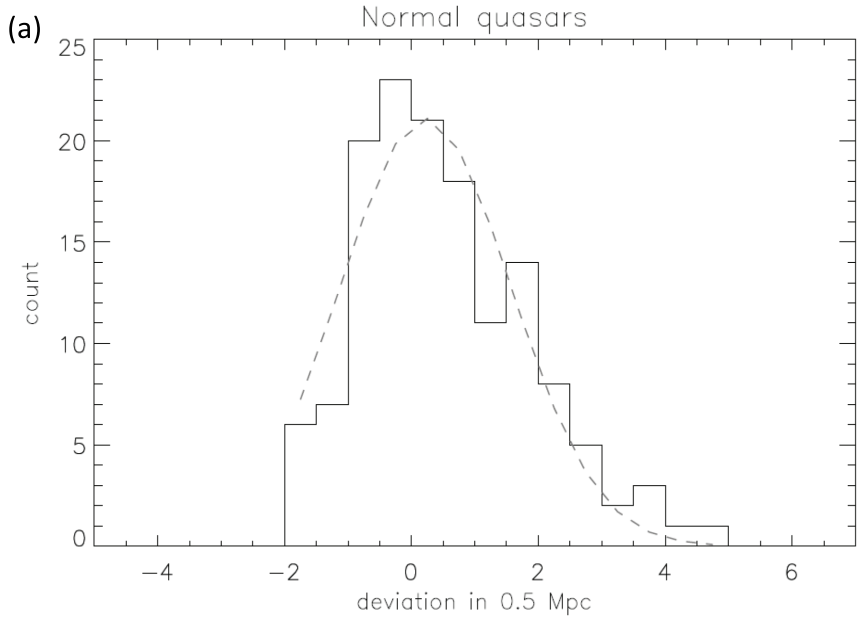


Figure 4. The distribution of galaxy number density deviation of red quasars in (a) 0.5 Mpc, (b) 1 Mpc and (c) 2 Mpc respectively. Total count includes F2M and UKFS, shaded part stands for UKFS red quasars.

In Figure 4, the distribution of deviation in 0.5 and 1 Mpc looks like a normal distribution, and their central peaks sit close to zero point. But the distribution of deviation in 2 Mpc has an excess at high deviation, which indicates much more red quasars located at the over dense or under dense environment in 2 Mpc scale.



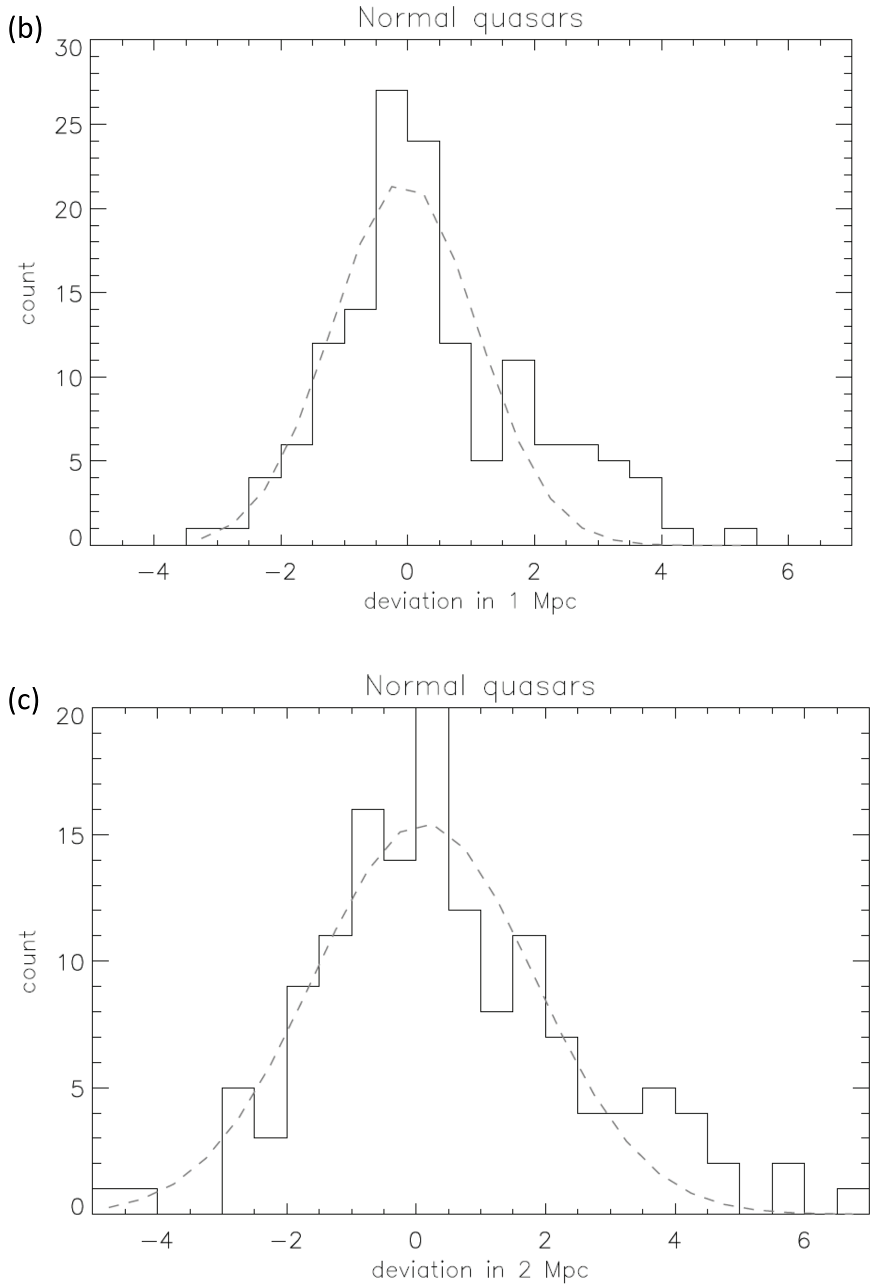


Figure 5. The distribution of galaxy number density deviation of normal quasars in (a) 0.5 Mpc, (b) 1 Mpc and (c) 2 Mpc respectively.

In Figure 5, the distribution of deviation in 0.5, 1 and 2 Mpc looks like normal distribution, but there are some excess at high deviation in 1 and 2 Mpc cases.

4. Discussion

Red quasars are not in the galaxy dense region

1) Disagree with our assumption SMBH merger occur in high density region
2) Red quasars show characteristics of SMBH merger (Glikman et al. 2015)

➔ SMBH merger do not favor in galaxy cluster

The neighbor galaxy density around normal and red quasars are similar

1) **If** red and normal quasars are in the same evolutionary sequence
   ➔ the evolution rate from red to normal quasars is quick, compared to the change of their environment.
2) **If** they are not related in evolution
   ➔ it might be the host galaxy that makes the difference even though they are in similar environment.

5. Conclusion

We studied the distribution of neighbor galaxies of both red and normal quasars, and found out that there are no strong evidence showing the preference of quasars (i.e., red and normal quasars study here) appearing in galaxy high density region. Furthermore, there is a similarity in the environments of red quasar and normal quasar. It might shows the close relationship in either galaxy evolutionary sequence or their host galaxy properties.

References

Glikman, E., Simmons, B., Mailly, M., et al. 2015, ApJ, 806, 218

Glikman, E., Urrutia, T., Lacy, M., et al. 2012, ApJ, 757, 51

Glikman, E., Urrutia, T., Lacy, M., et al. 2013, ApJ, 778, 127