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Comparison of some properties of star forming galaxies and active galactic nuclei between two BOSS galaxy samples from SDSS DR9 *

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Abstract Using the LOWZ and CMASS samples of the ninth data release (DR9) from the SDSS-III Baryon Oscillation Spectroscopic Survey (BOSS), I investigate properties of star forming galaxies and active galactic nuclei (AGNs). The CMASS sample seriously suffers from the radial selection effect, even within the redshift $0.44 \leq z \leq 0.6$, which will likely lead to statistical conclusions in the CMASS sample being less robust. In the LOWZ sample, the fraction of star-forming galaxies is nearly constant from the least dense regime to the densest regime; the AGN fraction is also insensitive to the local environment. In addition, I note that in the LOWZ sample, the distributions of stellar mass and stellar velocity dispersion for star forming galaxies and AGNs are nearly the same.

Key words: galaxies: active — galaxies: statistics

1 INTRODUCTION

In the past, some issues related to active galactic nuclei (AGNs) have been controversial. For example, the AGN fraction obtained in some works was fairly different, from a few percent to $\sim 40\%$ (Dressler et al. 1985; Huchra & Burg 1992; Ho et al. 1997; Carter et al. 2001; Ivezić et al. 2002; Miller et al. 2003; Deng et al. 2012a,c). This can be traced to two facts. First, these authors used different galaxy samples. Second, they applied different AGN classification techniques. Many works also focused on the environmental dependence of the AGN fraction, which can provide tests of models describing AGN activity and formation. In this aspect, typical studies included ones from Carter et al. (2001) and Miller et al. (2003), who reported that the AGN fraction depends very little on the environment. However, some authors argued that the AGN fraction should decrease with increasing density (e.g., Dressler et al. 1985; Kauffmann et al. 2004; Popesso & Biviano 2006; von der Linden et al. 2010; Deng et al. 2012c). Different environmental dependence of the AGN fraction actually means there are different physical mechanisms involved in AGN activity and formation.

Galaxy samples have often been divided into two opposite families, such as luminous and faint, red and blue, and early-type and late-type. Researchers often performed comparative studies between two such opposite families. For example, Deng et al. (2009a) and Deng (2010) compared some properties of early-type galaxies with those of late-type galaxies. Deng et al. (2011b) explored the

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environmental dependence of star formation rate (SFR), specific star formation rate (SSFR) and stellar mass for blue and red galaxies. Here, as a comparison, I also investigate some properties of star forming galaxies.

The Sloan Digital Sky Survey III (SDSS-III) (Eisenstein et al. 2011) Baryon Oscillation Spectroscopic Survey (BOSS) is a valuable project, which will carry out a redshift survey of 1.5 million luminous red galaxies (LRGs) at $0.15 < z < 0.8$ over 10 000 square degrees and 160 000 quasi-stellar objects (QSOs) at $2.15 < z < 3.5$ over 8000 square degrees. The public data release of BOSS spectral data includes a number of physical parameters for galaxies derived by some authors. Using principal component analysis, Chen et al. (2012) estimated stellar masses of $\sim 290\,000$ BOSS galaxies with stellar masses of $> 10^{11} M_{\odot}$ and a redshift range of $0.4 < z < 0.7$. By fitting model spectral energy distributions to *u, g, r, i, z* magnitudes, Maraston et al. (2013) calculated stellar masses for $\sim$400 000 BOSS galaxies at redshift $\sim$0.2–0.7. Thomas et al. (2013) measured stellar velocity dispersion and presented the BPT classification (Baldwin et al. 1981) of BOSS galaxies. These data sets will provide source material for the study of many issues related to galaxies.

My paper is organized as follows. In Section 2, I describe the data used. The density estimator and results are presented in Section 3 and Section 4, respectively. In Section 5, I compare some results of this work with previous ones. My main results and conclusions are summarized in Section 6.

In calculating the distance, I used a cosmological model with a matter density $\Omega_0 = 0.3$, cosmological constant $\Omega_\Lambda = 0.7$ and Hubble's constant $H_0 = 70\ \mathrm{km\,s^{-1}\,Mpc^{-1}}$.

2 DATA

The ninth data release (DR9) (Ahn et al. 2012) of the SDSS is the first public release of spectroscopic data from the SDSS-III BOSS, which includes 535 995 new galaxy spectra (median $z \sim 0.52$), 102 100 new quasar spectra (median $z \sim 2.32$), and 90 897 new stellar spectra, along with the data included in previous data releases.

The BOSS galaxy sample is divided into two principal samples at $z \sim 0.4$: "LOWZ" and "CMASS." The LOWZ sample is a low redshift sample, with a median redshift of $z = 0.3$, containing about a quarter of all galaxies in BOSS. This sample is a simple extension of the SDSS-I and -II Luminous Red Galaxy (LRG) sample (Eisenstein et al. 2001) to lower luminosities and allows for a comparison with the SDSS -I and -II samples. The space density of LOWZ galaxies is about 2.5 times that of the SDSS-I/II LRG sample. The CMASS sample, containing three times more galaxies than LOWZ, is designed to select galaxies above $z \sim 0.4$, and is a nearly complete sample of massive galaxies above the magnitude limit of the survey. The LOWZ sample mostly contains galaxies at $0.15 < z < 0.43$, while the CMASS sample mostly contains galaxies at $0.43 < z < 0.7$.

In this work, the data were downloaded from the Catalog Archive Server of SDSS DR9 (Ahn et al. 2012) by the SDSS SQL Search (*http://www.sdss3.org/dr9/*). I extracted 85 360 LOWZ galaxies with the redshift $0.15 \leq z \leq 0.43$ (with SDSS flag: BOSS_TARGET1&1>0) and 301 190 CMASS galaxies with the redshift $0.43 \leq z \leq 0.7$ (with SDSS flag: BOSS_TARGET1&128>0).

Maraston et al. (2013) employed the two template fittings (passive and star-forming) and the two adopted initial mass functions (IMFs) (Salpeter and Kroupa), and also considered mass lost via stellar evolution. In this work, I use the data of best-fit stellar mass [in log $M_{\odot}$] obtained with the star-forming template and the Kroupa IMF (*http://data.sdss3.org/sas/dr9/boss/spectro/redux/galaxy/*). The stellar mass of a few galaxies is 0 by definition. I remove these galaxies from the samples. Finally, the total number of galaxies in the LOWZ sample is reduced to 85 295, and the total number of galaxies in the CMASS sample is reduced to 296 501.

Thomas et al. (2013) performed a spectroscopic analysis of galaxy spectra from the SDSS-III BOSS. This data set was also released on the website: *http://data.sdss3.org/sas/dr9/boss/spectro/redux/galaxy/*. The BPT classification, first introduced by Baldwin et al. (1981), has been widely used in studies of SDSS galaxies, which has become standard practice in classifying objects according to their positions on the so-called BPT diagrams. Thomas et al. (2013) adopted the empirical separation between star forming galaxies and AGNs defined by Kauffmann et al. (2003). Star forming galaxies are the galaxies that lie below this line in BPT diagrams. The AGN population consists of galaxies above the theoretical extreme starburst line developed by Kewley et al. (2001). Composite galaxies are the objects that are between these two separating lines. This area is populated by galaxies with a combination of starburst and AGN spectra. Thomas et al. (2013) further used the dividing line defined by Schawinski et al. (2007) to distinguish between LINER and Seyfert emission based on SDSS galaxy classifications obtained through the [NII]/Hα ratio. In this data set, all analyses were restricted to those spectra where the full set of key diagnostic emission lines Hβ, [OIII], Hα and [NII] could be detected with an amplitude-over-noise (AoN) ratio above 1.5 (requiring the AoN ratio of all four lines to be larger than 1.5) to allow for a proper analysis of the emission line characteristics through emission line ratio diagnostic diagrams.

3 DENSITY ESTIMATOR

In this work, following Deng (2010), the three-dimensional local galaxy density LD (Galaxies Mpc^{-3}) is computed in a comoving sphere with a radius representing the distance to the 5th nearest galaxy for each galaxy. To explore environmental dependence of BOSS galaxy properties, as Deng et al. (2008) did, I arrange galaxies in order from the smallest to the largest, select approximately 5% of the galaxies, construct two subsamples at both extremes of density according to the density, and compare properties of BOSS galaxies in the least dense regime with those in the densest regime.

4 COMPARISON OF SOME PROPERTIES OF STAR FORMING GALAXIES AND AGNS BETWEEN TWO BOSS GALAXY SAMPLES FROM SDSS DR9

Table 1 shows the number of galaxies and fraction of different classes in the LOWZ and CMASS samples and different subsamples. As seen from this table, the fraction of star-forming galaxies in the LOWZ sample is nearly constant from the least dense regime to the densest regime.

In the CMASS sample with the redshift $0.43 \leq z \leq 0.7$, the fraction of star-forming galaxies dramatically increases with increasing density. This is likely due to the radial selection effect in the CMASS sample. Dawson et al. (2013) argued that the BOSS galaxies are selected to have an approximately uniform comoving number density of $\bar{n} = 3 \times 10^{-4}\ h^3\ \mathrm{Mpc}^{-3}$ out to a redshift $z = 0.6$, then monotonically decrease to zero density at $z \sim 0.8$. Figure 2 of Anderson et al. (2012) showed that the number density of CMASS galaxies dramatically drops with increasing redshift at $z > 0.6$. Thus, CMASS galaxies with low density preferentially exist in the redshift range $z > 0.6$, which leads to the CMASS subsample in the least dense regions containing a lower fraction of star-forming galaxies (Thomas et al. 2013). Thomas et al. (2013) argued that the fraction of star forming galaxies decreases and the fraction of AGNs increases with increasing redshift, mostly owing to selection effects.

Figure 1 shows the fraction of BLANK, Star Forming, Composite and AGN (Seyfert+ LINER+ Seyfert/LINER) classes as a function of redshift for the LOWZ and CMASS samples.

Figure 2 further demonstrates the fraction of different AGNs (Seyfert, LINER and Seyfert/LINER) as a function of redshift for the LOWZ and CMASS samples. In the LOWZ sample, selection effects are not very serious: the fraction of star forming galaxies is weakly redshift dependent and the fraction of AGNs slightly increases with increasing redshift. In the CMASS sample, the fraction of AGNs decreases with increasing redshift and the fraction of star forming galaxies slightly increases with redshift. It is noteworthy that at $z \sim 0.6$, the fraction of Star Forming, Composite and AGN classes dramatically drops to zero, while the fraction of the BLANK class reaches 1. This shows that selection effects in the CMASS sample are fairly serious. Maraston et al. (2013) also claimed that BOSS is a sample that has a uniform distribution of mass over the redshift range 0.2 to 0.6. Thus, I construct a sample from CMASS with redshift $0.44 \leq z \leq 0.6$, which contains 224 435

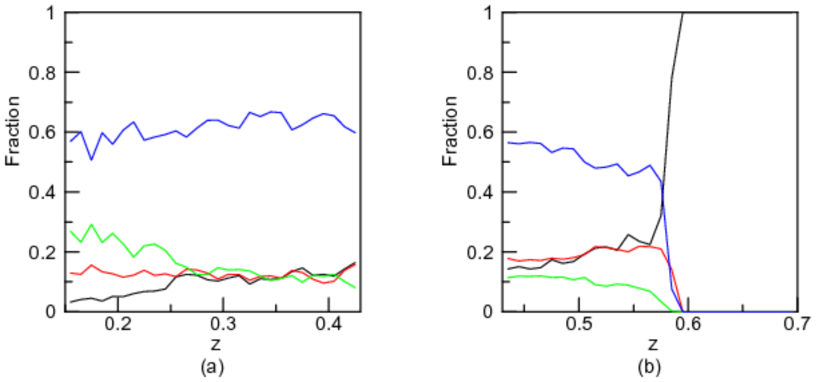

Fig. 1 Fraction of different classes as a function of redshift for the LOWZ (a) and CMASS (b) samples: black, red, green and blue lines represent BLANK, Star Forming, Composite and AGN (Seyfert + LINER + Seyfert/LINER), respectively.

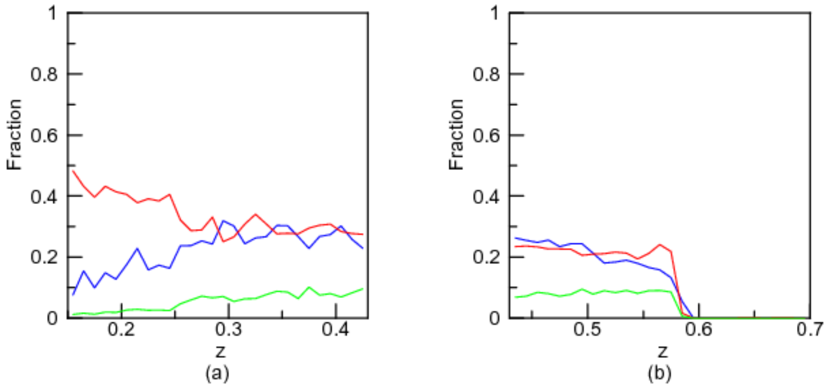

Fig. 2 Fraction of different AGNs as a function of redshift for the LOWZ (a) and CMASS (b) samples: blue, red, green lines represent Seyfert, LINER and Seyfert/LINER, respectively.

galaxies. This CMASS sample should be relatively uniform, in which the radial selection effect is less important. In the following analyses, I only use this CMASS sample. As seen in Table 1, in the CMASS sample with redshift $0.44 \leq z \leq 0.6$, the fraction of star-forming galaxies still increases with increasing density.

Table 1 demonstrates that the fraction of each class in two BOSS galaxy samples is fairly different, which shows that the fraction of each class is seriously influenced by the properties of the BOSS galaxy samples.

The study of the environmental dependence of the AGN fraction has long been an important issue, which can provide tests of models of AGN activity and formation. Miller et al. (2003) argued that independence between the local galaxy density and the AGN fraction may mean that the AGN population is primarily tracing only the bulge component of galaxies. Miller et al. (2003) also claimed that if there is a strong correlation between the presence of an AGN and the ability of a galaxy to form stars, the AGN fraction should decrease with increasing density, analogous to the SFR-density relation (e.g., Balogh et al. 1998; Hashimoto et al. 1998; Lewis et al. 2002; Gómez et al. 2003; Tanaka et al. 2004; Patel et al. 2009). If galaxy-galaxy collisions fuel the AGN activity

Table 1 Number of galaxies and fraction of different classes in the LOWZ and CMASS samples and different subsamples.

Sample	All N (100%)	BLANK N (%)	Star Forming N (%)	Composite N (%)	Seyfert N (%)	LINER N (%)	Seyfert/LINER N (%)
LOWZ sample ($0.15 \leq z \leq 0.43$)	85295	9364 (11.0)	10511 (12.3)	12019 (14.1)	21201 (24.9)	26670 (31.3)	5530 (6.4)
LOWZ subsample ($0.15 \leq z \leq 0.43$) at the lowest density (LD=$5.18 \times 10^{-8} - 1.71 \times 10^{-5}$ galaxies Mpc^{-3})	4265	440 (10.3)	574 (13.5)	700 (16.4)	988 (23.2)	1324 (31.0)	239 (5.6)
LOWZ subsample ($0.15 \leq z \leq 0.43$) at the highest density (LD=$1.11 \times 10^{-3} - 3.91 \times 10^{-2}$ galaxies Mpc^{-3})	4265	464 (10.9)	580 (13.6)	655 (15.4)	942 (22.1)	1355 (31.7)	269 (6.3)
CMASS sample ($0.43 \leq z \leq 0.70$)	296501	130963 (44.2)	42052 (14.2)	19474 (6.6)	42130 (14.2)	44705 (15.1)	17177 (5.7)
CMASS subsample ($0.43 \leq z \leq 0.70$) at the lowest density (LD=$1.44 \times 10^{-6} - 2.39 \times 10^{-5}$ galaxies Mpc^{-3})	14825	12296 (82.9)	611 (4.1)	334 (2.3)	666 (4.5)	689 (4.6)	229 (1.6)
CMASS subsample ($0.43 \leq z \leq 0.70$) at the highest density (LD=$1.75 \times 10^{-3} - 1.16 \times 10^{-1}$ galaxies Mpc^{-3})	14825	3904 (26.3)	2614 (17.6)	1199 (8.1)	2788 (18.8)	3064 (20.7)	1256 (8.5)
CMASS sample ($0.44 \leq z \leq 0.60$)	224435	62534 (27.9)	41296 (18.4)	18991 (8.5)	41019 (18.3)	43706 (19.5)	16889 (7.4)
CMASS subsample ($0.44 \leq z \leq 0.60$) at the lowest density (LD=$3.52 \times 10^{-6} - 3.83 \times 10^{-5}$ galaxies Mpc^{-3})	11222	4425 (39.4)	1746 (15.6)	848 (7.6)	1712 (15.3)	1834 (16.3)	657 (5.8)
CMASS subsample ($0.44 \leq z \leq 0.60$) at the highest density (LD=$2.05 \times 10^{-3} - 1.16 \times 10^{-1}$ galaxies Mpc^{-3})	11222	2686 (23.9)	2044 (18.2)	951 (8.5)	2165 (19.3)	2390 (21.3)	986 (8.8)

Notes: 1. BPT=‘BLANK’ means no classification could be made, usually because one of the lines involved has an ‘NaN’ or ‘Inf’ value in the catalog. 2. Seyfert/LINER denote those cases where the line ratios happen to sit exactly on the dividing line.

by driving gas into the cores of galaxies and thus onto the black hole (BH; Gunn 1979; Shlosman et al. 1990), the fraction of galaxies with an AGN should increase with increasing local density.

As seen from Table 1, the AGN (Seyfert + LINER + Seyfert/LINER) fraction of two subsamples at both extremes of density in the LOWZ sample is: 59.8% for the subsample at low density and 60.1% for the subsample at high density, which shows that the AGN fraction is insensitive to the local environment. However, in the CMASS sample with redshift $0.44 \leq z \leq 0.6$, the AGN fraction increases considerably with increasing density: 37.4% for the subsample at low density and 49.4% for the subsample at high density. This is still due to the radial selection effect. As seen

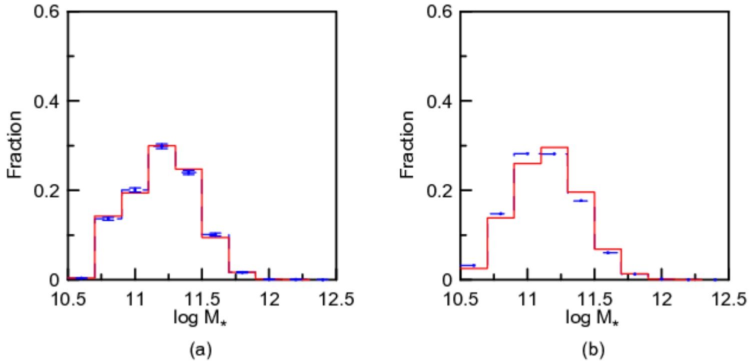

Fig. 3 Stellar mass distribution of star forming galaxies and AGNs for the LOWZ (a) and CMASS (b) samples: red solid lines denote AGNs and blue dashed lines represent star forming galaxies. The error bars of blue lines are 1σ Poissonian errors. Error bars of red lines are omitted for clarity.

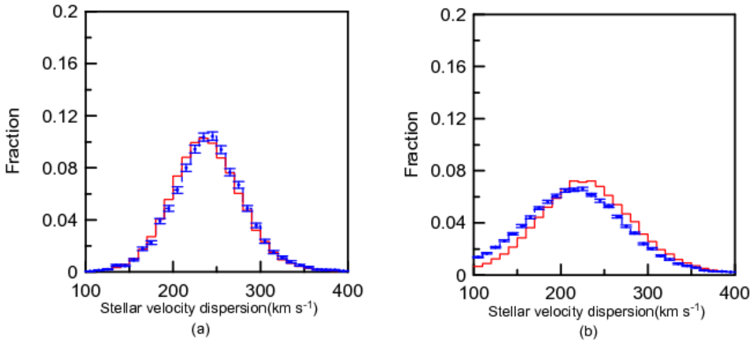

Fig. 4 Stellar velocity dispersion distribution of star forming galaxies and AGNs for the LOWZ (a) and CMASS (b) samples: red solid lines denote AGNs and blue dashed lines represent star forming galaxies. The error bars of blue lines are 1σ Poissonian errors. Error bars of red lines are omitted for clarity.

from Figure 1, at $z \sim 0.6$, the AGN fraction dramatically drops to zero. Figure 2 of Anderson et al. (2012) showed that the number density of CMASS galaxies reaches the peak value at $z \sim 0.53$, then decreases substantially with increasing redshift. Thus, most CMASS galaxies with low density are likely located at $z \sim 0.6$, which leads to the CMASS subsample in the least dense regions containing a lower AGN fraction.

It is noteworthy that the fraction of BLANK class in the CMASS sample is fairly high, which means that classification of relatively many galaxies could not be made. Such a drawback will likely lead to statistical conclusions in the CMASS sample being less robust. CMASS galaxies are mostly located at $z > 0.45$. Thomas et al. (2013) indicated that the analysis of AGN fractions at high redshifts requires alternative methods for the identification of AGNs, which is a topic of future work.

Figure 3 shows the stellar mass distribution of star forming galaxies and AGNs for the LOWZ (a) and CMASS (b) samples. In the LOWZ sample, the stellar mass distribution of star forming galaxies and AGNs is nearly the same. In the CMASS sample, a weak trend can be observed: AGNs are preferentially more massive, however, this is likely due to the radial selection effect.

Figure 4 shows the stellar velocity dispersion distribution of star forming galaxies and AGNs for the LOWZ (a) and CMASS (b) samples. Only in the CMASS sample does an apparent trend exist: AGNs have preferentially larger stellar velocity dispersion. Thomas et al. (2013) argued that the typical velocity dispersion of a BOSS galaxy is $\sim 240\ \mathrm{km\ s^{-1}}$. Indeed, the peak value of the distribution of stellar velocity dispersion in the two samples is at $\sim 240\ \mathrm{km\ s^{-1}}$.

5 COMPARISON WITH PREVIOUS RESULTS

Deng et al. (2012a) reported that in the two volume-limited main galaxy (Strauss et al. 2002) samples of the SDSS Data Release 8 (SDSS DR8) (Aihara et al. 2011), the fraction of star-forming galaxies decreases with density, which is in good agreement with previous results (Carter et al. 2001; Miller et al. 2003; Deng et al. 2009b, 2011a). Such a trend means that high density environments tend to suppress star formation (e.g., Balogh et al. 1998; Hashimoto et al. 1998; Lewis et al. 2002; Gómez et al. 2003; Tanaka et al. 2004; Patel et al. 2009), which is suggested by many possible mechanisms (Gunn & Gott 1972; Byrd & Valtonen 1990; Zabludoff et al. 1996; Zabludoff & Mulchaey 1998; Moore et al. 1999; Quilis et al. 2000). However, Deng et al. (2012b) found that the environmental dependence of SFR and SSFR in the LRG sample is fairly weak. LRGs are a group of galaxies that are likely to be luminous, red and early-type. Deng et al. (2012b) argued that weak environmental dependence of SFR and SSFR in the LRG sample can be traced to two facts. First, galaxy color and morphology are a pair of galaxy properties most predictive of local environments. Second, strong environmental dependence of galaxy properties for red galaxies is mainly due to the environmental dependence in the red late-type sample (Deng et al. 2011b). As indicated above, the LOWZ sample is only a simple extension of the SDSS-I and -II LRG sample. Thus, it is not surprising that there is nearly no correlation between the fraction of star-forming galaxies and the local density in the LOWZ sample.

As seen in Table 1, the AGN (Seyfert, LINER and Seyfert/LINER) fraction in the LOWZ sample is $\sim$ 62.6% and this fraction in the CMASS sample with redshift $0.44 \le z \le 0.6$ is $\sim$ 45.2%, which is much larger than results obtained in previous works. Dressler et al. (1985) and Huchra & Burg (1992) reported that only a few percent of galaxies possessed an AGN. Ivezić et al. (2002) also claimed that only 5% of SDSS galaxies had an AGN. Miller et al. (2003) showed that the AGN fraction in the early data release of the SDSS (Stoughton et al. 2002) is about 20%, which is closer to that found in the survey by Carter et al. (2001). In two volume-limited main galaxy samples of the SDSS DR6 (Adelman-McCarthy et al. 2008) above and below the value of M_r^*, Deng et al. (2012c) demonstrated that the AGN fraction in the luminous volume-limited sample is $\sim$ 9.8% and the AGN fraction in the faint volume-limited sample is $\sim$ 4.3%. Deng et al. (2012a) argued the difference in the AGN fraction obtained by different authors is likely due to these authors using different AGN classification techniques. However, in the works of Deng et al. (2012a) and Deng et al. (2012c), the two volume-limited main galaxy samples above and below the value of M_r^* contain fairly different AGN fractions, even if the same AGN classification techniques were used in the two samples. Deng et al. (2012a) and Deng et al. (2012c) argued that the AGN fraction is also seriously influenced by the properties of galaxy samples. Deng et al. (2012a) used physical parameters of galaxies derived by the MPA-JHU group (*http://www.mpa-garching.mpg.de/SDSS/DR7/*), such as BPT classification, stellar mass, nebular oxygen abundance, SFRs and the SSFR. The BPT classification in this website is based on the methodology of Brinchmann et al. (2004), which is completely the same as the methodology of Thomas et al. (2013) that is adopted in this work. However, the AGN fraction in the two BOSS galaxy samples is much larger than that found in the two volume-limited main galaxy samples by Deng et al. (2012a). This further shows that the AGN fraction is indeed correlated with some properties of galaxy samples.

Kauffmann et al. (2003) argued that AGNs at all luminosities as measured by the [OIII]λ 5007 emission line reside almost exclusively in massive galaxies. Deng et al. (2012a) concluded that galaxies hosting AGNs are preferentially more massive. For a long time, supermassive BHs were hypothesized to be the power source of AGNs (Salpeter 1964; Lynden-Bell & Sanitt 1969). Heckman et al. (2004) reported that most present-day accretion occurs onto BHs that reside in moderately massive galaxies ($M_* \simeq 10^{10} - 10^{11.5} M_\odot$). However, I calculate the fraction of moderately massive galaxies in different galaxy samples: 88.75% in the LOWZ sample, 90.88% in the CMASS sample with the redshift 0.44 $< z <$0.6, 32.86% in the faint volume-limited sample of Deng et al. (2012a) and 98.49% in the luminous volume-limited sample of Deng et al. (2012a), which does not support this viewpoint. Deng et al. (2012c) also argued that the presence of AGNs is not correlated with stellar mass. They demonstrated that about 70.82% of luminous hosts with an AGN are high mass galaxies, but this fraction in faint hosts with an AGN is only 3.73%.

Carter et al. (2001) and Deng et al. (2012c) demonstrated that the AGN fraction increases steeply with luminosity. BOSS galaxies are a group of fairly luminous galaxies, compared with previous galaxy samples. A high fraction of AGNs in BOSS galaxy samples is likely due to the correlation between the presence of AGNs and luminosity.

Numerous authors showed that the AGN fraction nearly does not correlate with the local environment of AGN host galaxies (e.g., Monaco et al. 1994; Coziol et al. 1998; Shimada et al. 2000; Carter et al. 2001; Schmitt 2001; Miller et al. 2003; Pasquali et al. 2009). However, there have been a number of dissenting papers. Dressler et al. (1985) and Popesso & Biviano (2006) reported a lower fraction of AGNs in clusters than in the field. Kauffmann et al. (2004) argued that galaxies in dense environments are less likely to host a powerful optical AGN (L[OIII] $> 10^7 L_\odot$). von der Linden et al. (2010) claimed that the overall fraction of strong AGNs decreases towards the cluster center. Deng et al. (2012c) showed that the fraction of AGNs declines substantially with increasing local density in the luminous volume-limited sample, but in the faint volume-limited sample this change is very weak. Deng et al. (2012a) argued that such a controversial conclusion is also likely due to these authors using different AGN classification techniques and galaxy samples. For example, in the two volume-limited main galaxy samples of the SDSS DR8, Deng et al. (2012a) found that the AGN fraction is nearly insensitive to the local environment, which is not consistent with the conclusion of Deng et al. (2012c). Deng et al. (2012c) used the empirical demarcation line between star-forming galaxies and AGNs developed by Kauffmann et al. (2003). Thus, AGN samples of Deng et al. (2012c) actually contain composite galaxies (C) and AGN populations. Deng et al. (2012a) indicated that if composite galaxies (C) are classified as AGNs as Deng et al. (2012c) did, the fraction of AGNs in the luminous volume-limited sample declines with increasing local density.

Kauffmann et al. (2004) argued that the fraction of strong AGNs in massive galaxies decreases as a function of density, but the fraction of low-luminosity AGNs depends very little on local density. Miller et al. (2003) reported that the AGN fraction shows little dependence on local density. Kauffmann et al. (2004) claimed that it is likely due to their sample containing a substantial number of weak AGNs. Kauffmann et al. (2004) indicated that AGNs with L[OIII] $> 10^7 L_\odot$ are almost all type 2 Seyfert galaxies, but low-luminosity AGNs are LINERs. However, Table 1 demonstrates that in the LOWZ sample, both the fraction of Seyfert and LINER classes are nearly independent of the local environment. As indicated in Deng et al. (2012c), this shows that the classification of AGNs does not essentially decide whether the AGN fraction depends on the environment.

6 SUMMARY

Using the LOWZ and CMASS samples from the DR9 of SDSS-III BOSS, I investigate properties of star forming galaxies and AGNs. The main results can be summarized as follows:

(1) The CMASS sample seriously suffers from the radial selection effect, even within the redshift $0.44 \leq z \leq 0.6$, which will lead to statistical conclusions in the CMASS sample likely being less robust. Thomas et al. (2013) indicated that the analysis of AGN fractions at high redshifts requires alternative methods for the identification of AGNs. Improvement of all these drawbacks in a CMASS sample should be a focus of future works.

(2) The fraction of each class in two BOSS galaxy samples is fairly different, which shows that the fraction of each class is seriously influenced by the properties of BOSS galaxy samples.
(3) In the LOWZ sample, the fraction of star-forming galaxies is nearly constant from the least dense regime to the densest regime, which is consistent with results of LRGs.
(4) The AGN (Seyfert, LINER and Seyfert/LINER) fraction in the LOWZ sample is $\sim$ 62.6% and this fraction in the CMASS sample with redshift $0.44 \leq z \leq 0.6$ is $\sim$ 45.2%, which is much larger than results obtained in previous works.
(5) In the LOWZ sample, the AGN fraction is insensitive to the local environment.
(6) In the LOWZ sample, distributions of stellar mass and stellar velocity dispersion for star forming galaxies and AGNs are nearly the same.

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References

Adelman-McCarthy, J. K., Agüeros, M. A., Allam, S. S., et al. 2008, ApJS, 175, 297
Ahn, C. P., Alexandroff, R., Allende Prieto, C., et al. 2012, ApJS, 203, 21
Aihara, H., Allende Prieto, C., An, D., et al. 2011, ApJS, 193, 29
Anderson, L., Aubourg, E., Bailey, S., et al. 2012, MNRAS, 427, 3435
Baldwin, J. A., Phillips, M. M., & Terlevich, R. 1981, PASP, 93, 5 (BPT)
Balogh, M. L., Schade, D., Morris, S. L., et al. 1998, ApJ, 504, L75
Brinchmann, J., Charlot, S., White, S. D. M., et al. 2004, MNRAS, 351, 1151
Byrd, G., & Valtonen, M. 1990, ApJ, 350, 89
Carter, B. J., Fabricant, D. G., Geller, M. J., Kurtz, M. J., & McLean, B. 2001, ApJ, 559, 606
Chen, Y.-M., Kauffmann, G., Tremonti, C. A., et al. 2012, MNRAS, 421, 314
Coziol, R., de Carvalho, R. R., Capelato, H. V., & Ribeiro, A. L. B. 1998, ApJ, 506, 545
Dawson, K. S., Schlegel, D. J., Ahn, C. P., et al. 2013, AJ, 145, 10
Deng, X.-F. 2010, ApJ, 721, 809
Deng, X.-F., He, J.-Z., Jun, S., Ping, W., & Liao, Q.-H. 2008, PASP, 120, 487
Deng, X.-F., He, J.-Z., & Wen, X.-Q. 2009a, ApJ, 693, L71
Deng, X.-F., He, J.-Z., Chen, Y.-Q., Song, J., & Jiang, P. 2009b, ApJ, 706, 436
Deng, X.-F., Chen, Y. Q., Jiang, P., Ding, Y. P., & Song, J. 2011a, Astronomische Nachrichten, 332, 706
Deng, X.-F., Chen, Y.-Q., & Jiang, P. 2011b, MNRAS, 417, 453
Deng, X.-F., Xin, Y., Wu, P., et al. 2012a, ApJ, 754, 82
Deng, X.-F., Yang, B., Ding, Y.-P., & Jiang, P. 2012b, Astronomische Nachrichten, 333, 644
Deng, X.-F., Xin, Y., Wu, P., et al. 2012c, Astronomische Nachrichten, 333, 767

Dressler, A., Thompson, I. B., & Shectman, S. A. 1985, ApJ, 288, 481
Eisenstein, D. J., Annis, J., Gunn, J. E., et al. 2001, AJ, 122, 2267
Eisenstein, D. J., Weinberg, D. H., Agol, E., et al. 2011, AJ, 142, 72
Gómez, P. L., Nichol, R. C., Miller, C. J., et al. 2003, ApJ, 584, 210
Gunn, J. E., & Gott, J. R., III 1972, ApJ, 176, 1
Gunn, J. E. 1979, Feeding the Monster - Gas Discs in Elliptical Galaxies in Active Galactic Nuclei, eds. C. Hazard, & S. Mitton (Cambridge: Cambridge Univ. Press), 213
Hashimoto, Y., Oemler, A., Jr., Lin, H., & Tucker, D. L. 1998, ApJ, 499, 589
Heckman, T. M., Kauffmann, G., Brinchmann, J., et al. 2004, ApJ, 613, 109
Ho, L. C., Filippenko, A. V., & Sargent, W. L. W. 1997, ApJ, 487, 568
Huchra, J., & Burg, R. 1992, ApJ, 393, 90
Ivezić, Ž., Menou, K., Knapp, G. R., et al. 2002, AJ, 124, 2364
Kauffmann, G., Heckman, T. M., Tremonti, C., et al. 2003, MNRAS, 346, 1055
Kauffmann, G., White, S. D. M., Heckman, T. M., et al. 2004, MNRAS, 353, 713
Kewley, L. J., Dopita, M. A., Sutherland, R. S., Heisler, C. A., & Trevena, J. 2001, ApJ, 556, 121
Lewis, I., Balogh, M., De Propris, R., et al. 2002, MNRAS, 334, 673
Lynden-Bell, D., & Sanitt, N. 1969, MNRAS, 143, 167
Maraston, C., Pforr, J., Henriques, B. M., et al. 2013, MNRAS, 435, 2764
Miller, C. J., Nichol, R. C., Gómez, P. L., Hopkins, A. M., & Bernardi, M. 2003, ApJ, 597, 142
Monaco, P., Giuricin, G., Mardirossian, F., & Mezzetti, M. 1994, ApJ, 436, 576
Moore, B., Lake, G., Quinn, T., & Stadel, J. 1999, MNRAS, 304, 465
Pasquali, A., van den Bosch, F. C., Mo, H. J., Yang, X., & Somerville, R. 2009, MNRAS, 394, 38
Patel, S. G., Holden, B. P., Kelson, D. D., Illingworth, G. D., & Franx, M. 2009, ApJ, 705, L67
Popesso, P., & Biviano, A. 2006, A&A, 460, L23
Quilis, V., Moore, B., & Bower, R. 2000, Science, 288, 1617
Salpeter, E. E. 1964, ApJ, 140, 796
Schawinski, K., Thomas, D., Sarzi, M., et al. 2007, MNRAS, 382, 1415
Schmitt, H. R. 2001, AJ, 122, 2243
Shimada, M., Ohyama, Y., Nishiura, S., Murayama, T., & Taniguchi, Y. 2000, AJ, 119, 2664
Shlosman, I., Begelman, M. C., & Frank, J. 1990, Nature, 345, 679
Stoughton, C., Lupton, R. H., Bernardi, M., et al. 2002, AJ, 123, 485
Strauss, M. A., Weinberg, D. H., Lupton, R. H., et al. 2002, AJ, 124, 1810
Tanaka, M., Goto, T., Okamura, S., Shimasaku, K., & Brinkmann, J. 2004, AJ, 128, 2677
Thomas, D., Steele, O., Maraston, C., et al. 2013, MNRAS, 431, 1383
von der Linden, A., Wild, V., Kauffmann, G., White, S. D. M., & Weinmann, S. 2010, MNRAS, 404, 1231
Zabludoff, A. I., & Mulchaey, J. S. 1998, ApJ, 496, 39
Zabludoff, A. I., Zaritsky, D., Lin, H., et al. 1996, ApJ, 466, 104