Stellar and gaseous velocity dispersions in type II AGNs at $0.3 < z < 0.83$ from the Sloan Digital Sky Survey

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ABSTRACT

We apply the stellar population synthesis code by Cid Fernandes et al. to model the stellar contribution for a sample of 209 type II AGNs at redshifts $0.3 < z < 0.83$ from the Sloan Digital Sky Survey. The reliable stellar velocity dispersions ($\sigma_*$) are obtained for 33 type II AGNs with significant stellar absorption features. According to the $L_{\text{OIII}}$ criterion of $3 \times 10^8 L_\odot$, 20 of which can be classified as type II quasars. We use the formula of Greene & Ho to obtain the corrected stellar velocity dispersions ($\sigma_*$). We also calculate the supermassive black holes masses from $\sigma_*$ in these high-redshift type II AGNs. The [O III] luminosity is correlated with the black hole mass, and no correlation is found between the [O III] luminosity and the Eddington ratio. Three sets of two-component profiles are used to fit multiple emission transitions ([O III]λλ4959, 5007 and [O II]λλ3727, 3729) in these 33 stellar-light substracted spectra. We also measure the gas velocity dispersions ($\sigma_g$) from these multiple transitions, and find that $\sigma_g$ can trace $\sigma_*$ (although with considerable scatter), which confirms that the gaseous kinematics of narrow line regions in these type II quasars are primarily dominated by the gravitational potential of the bulge. The distribution of $<\sigma_g/\sigma_*>$ is $1.24 \pm 0.76$ for the core [O III] line and $1.20 \pm 0.96$ for the [O II] line, which suggests that $\sigma_g$ of the core [O III] and [O II] lines can trace $\sigma_*$ within about 0.1 dex in the logarithm of $\sigma_*$. For the secondary driver, we find that the deviation of $\sigma_g$ from $\sigma_*$ is correlated with the Eddington ratio.

Key words: galaxies:active — galaxies:nuclei — quasars: emission lines

1 INTRODUCTION

Recent advances on the study of normal galaxies and active galactic nuclei (AGNs) are that we found more evidence for the existence of central supermassive black holes (SMBHs) and the relationship between SMBHs and bulge properties of host galaxies (Gebhardt et al. 2000; Ferrarese & Merritt 2000; Tremaine et al. 2002; Begelman 2003; Shen et al. 2005). We can use the stellar and/or gaseous dynamics to derive the SMBHs masses in nearby inactive galaxies. However, it is much more difficult for the case of AGNs. With the broad emission lines from broad-line regions (BLRs) (e.g. Hβ, Mg II, CIV; Hα), the reverberation mapping method and the empirical size-luminosity relation can be used to derive the virial SMBHs masses in AGNs (Kaspi et al. 2000; Vestergaard 2002; McLure & Jarvis 2002; Wu et al. 2004; Greene & Ho 2006a). It has been found that nearby galaxies and AGNs follow the same strong correlation between the central SMBHs masses ($M_{\text{BH}}$) and stellar bulge velocity dispersion ($\sigma_*$) (the $M_{\text{BH}} - \sigma_*$ relation) (Nelson et al. 2001; Tremaine et al. 2002; Greene & Ho 2006a, 2006b), which also implied that the mass from reverberation mapping method is reliable.

According to the unification model of active galactic nuclei (e.g. Antonucci 1993; Urry & Padovani 1995), AGNs can be classified into two classes depending on whether the central engine and BLRs are viewed directly (type I AGNs) or are obscured by circumnuclear medium (type II AGNs). In type I AGNs, by using the broad emission lines from BLRs (the reverberation mapping method or the empirical size-luminosity relation), we can derive virial SMBHs masses. It is not easy to study their host galaxies because their optical spectra are dominated by the non-stellar emission. This is especially true for luminous AGNs, where the continuum radiation from central source outshines the stellar light from the host galaxy.

In type II AGNs, the obscuration of BLRs makes both the reverberation mapping method and the empirical size-luminosity relation impossible to derive SMBHs masses.
However, we can use the well-known $M_{BH} - \sigma_*$ relation to derive SMBHs masses if we can accurately measure the stellar bulge velocity dispersion ($\sigma_*$). There are mainly two methods to measure $\sigma_*$: one is in Fourier space (e.g. Tonry & Davis 1979), the other is in pixel space (e.g. Greene & Ho 2006b and reference therein). These years it is popular to use the combination of galaxy template spectra broadened by a Gaussian kernel (e.g. Kauffmann et al. 2003; Cid Fernandes et al. 2004a; Greene & Ho 2006b). Though it is still not an easy task to measure $\sigma_*$, it has been shown successfully to derive $\sigma_*$ through fitting stellar absorption features: such as Ca II $\lambda\lambda 8498, 8542, 8662$ triplet, Mg I $\lambda\lambda 5167, 5173, 5184$ triplet, and Ca H+K $\lambda\lambda 3969, 3934$, etc.

On the other hand, Nelson & Whittle (1996) find that the gaseous velocity dispersion ($\sigma_g$) of [O III]$\lambda\lambda 5007$ from the narrow-line regions (NLRs) is nearly the same as $\sigma_*$ for a sample of 66 Seyfert galaxies, and suggest that the gaseous kinematics of NLRs be primarily governed by the bulge gravitational potential. Nelson (2000) find a tight relation between $M_{BH}$ and $\sigma_{GHI}$ (the [O III]$\lambda\lambda 5007$ velocity dispersion) for AGNs, very similar to the relation of $M_{BH} - \sigma_*$, although with more scatter, which strongly suggests that $\sigma_g$ can be used as a proxy for $\sigma_*$. For lower-redshift type II AGNs with $0.02 < z < 0.3$, Kauffmann et al. (2003) have investigated the properties of their hosts from the Sloan Digital Sky Survey (SDSS) Data Release One (DR1), measured $\sigma_*$ and estimated the SMBHs masses from $\sigma_*$, (Brinchmann et al. 2004). By using this sample, Greene & Ho (2005) measured the gaseous velocity dispersion ($\sigma_g$) from multiple transitions ([O II] $\lambda\lambda 3727, \lambda\lambda 5007$, and [S II] $\lambda\lambda 6716, 6731$) and compared $\sigma_*$ and $\sigma_g$. They found that $\sigma_g$ from these multiple transitions trace $\sigma_*$ very well, although for some emission features showing considerable scatter.

Type II quasars are the luminous analogs of low-luminosity type II (Seyfert 2) galaxies. The obscuration of BLRs makes quasars appear to be type II quasars (obscured quasars). Some methods have been used to discover type II quasars, but only a handful have been found. Recently, Zakamsa et al. (2003) present a sample of 291 type II AGNs at redshifts $0.3 < z < 0.83$ from the SDSS spectroscopic data. About half are type II quasars if we use the [O III] $\lambda\lambda 5007$ line luminosity to represent the strength of the nuclear activity. How about the $\sigma_* - \sigma_g$ relation for type II quasars? And how about their SMBHs masses and the Eddington ratios $L_{bol}/L_{edd}$ (i.e. the bolometric luminosity as a fraction of the Eddington luminosity)?

Here we used the sample of Zakamsa et al. (2003) to study these questions in type II quasars. In section 2, we introduce the data and the analysis. Our results and discussion are given in Sec. 3. All of the cosmological calculations in this paper assume $H_0 = 70$ km s$^{-1}$ Mpc$^{-1}$, $\Omega_M = 0.3$, $\Omega_{\Lambda} = 0.7$.

## 2 DATA AND ANALYSIS

With SDSS, Zakamsa et al. (2003) present a sample of 291 type II AGNs at redshifts $0.3 < z < 0.83$. We download these spectra from SDSS Data Release Four (DR4) and the spectra for 202 type II AGNs at redshifts $0.3 < z < 0.83$ are obtained. SDSS spectra cover 3800-9200 Å, with resolution ($\lambda/\Delta\lambda$) of 1800 $< R < 2100$ and sampling of 2.4 pixels per resolution element. The fibers in the SDSS spectroscopic survey have a diameter of 3" on the sky, for our Type II AGNs sample at redshifts $0.3 < z < 0.83$, the projected fibre aperture diameter typically contains about 90% of the total host galaxy light (Kauffmann & Heckman 2005), and thus makes it feasible to observe significant stellar absorption features, which is the key point to accurately measure the stellar velocity dispersion ($\sigma_*$) in this paper.

We first model the stellar contribution in the SDSS spectra of type II AGNs through the modified version of the stellar population synthesis code, STARLIGHT (version 2.0, Cid Fernandes et al. 2001; Cid Fernandes et al. 2004a; Cid Fernandes et al. 2004b; Garcia-Rissman et al. 2005), which adopted the new stellar library from Bruzual & Charlot (2003). The code does a search for the linear combination of Simple Stellar Populations (SSP) to match a given observed spectrum $O_\lambda$. The model spectrum $M_\lambda$ is:

$$M_\lambda(x, M_{BH}, A_V, \nu, \sigma_*) = M_\lambda^0 \sum_{j=1}^N x_j b_j \lambda \sigma_*$

where $b_j \lambda \lambda = L_{SSP}(x_j, Z_j)/L_{SSP}(x_j, Z_0)$ is the spectrum of the $j$th SSP normalized at $\lambda_0$, $x_j \equiv 10^{-0.4(A_{\lambda_0} - A_{\lambda})}$ is the reddening term, $x$ is the population vector, $M_{BH}$ is the synthetic flux at the normalization wavelength, $G(\nu, \sigma_*)$ is the line-of-sight stellar velocity distribution, modeled as a Gaussian centered at velocity $\nu$, and broadened by $\sigma_*$. The match between model and observed spectra is calculated by the $\chi^2(x, M_{BH}, A_V, \nu, \sigma_*) = \sum_{\lambda \in \Lambda} \left[ (O_\lambda - M_\lambda) w_\lambda \right]^2$, where the weight spectrum $w_\lambda$ is defined as the inverse of the noise in $O_\lambda$. For more detail, please refer to Cid Fernandes et al. (2005).

Prior to the synthesis, the Galactic extinction is corrected by using the extinction law of Cardelli, Clayton & Mathis (1989) and the $A_V$ value from Schlegel, Finkbeiner & Davis (1998) as listed in the NASA/IPAC Extragalactic Database (NED). The spectra are transformed into the rest frame defined by the redshift given in their FITS header. The spectrum is normalized at 4020Å and the signal-to-noise ratio is measured in the S/N window between 4730 and 4780 Å. Masks of 20 – 30 Å around obvious emission lines are constructed for each object individually. Because the redshift coverage of this type II AGNs sample, we focus on the strongest stellar absorption features of Ca II k and the G-band, which are less affected by nearby emission lines. An $f_v \sim \nu^{-1.5}$ power-law component is used to account for the contribution from the AGN continuum emission (Watanabe et al. 2003). Finally we check visually our spectral fitting results one by one.

For our sample, the S/N in the S/N window varies between 0.3 and 21.5. The fitting results for high S/N objects are usually better than those for low S/N ones. After inspecting the fitting results, we find that the fitting goodness depends not only on the S/N (> 5), but also on the absorption lines equivalent widths ($EW_\lambda > 1.5\AA$). At last we select 33 type II AGNs, which are shown significant stellar absorption features and are well fitted to derive reliable measurement of stellar velocity dispersion $\sigma_*$. The [O III]$\lambda\lambda 5007$ luminosity ($L_{[OIII]}$) is subject to extinction by interstellar dust in the host galaxy and in our Galaxy, which is usually corrected by using the Balmer decrement. However, for most objects in the sample of Za-
kansa et al. (2003), Ho cannot be showed in SDSS spectra. Therefore the extinction is not corrected. In order to check that these sub-sample is representative of total sample of Zakamsa et al. (2003) respect to [O III]λ5007 luminosity \( L_{\text{[OIII]}} \), we plotted the histograms of the \( L_{\text{[OIII]}} \) distribution for sub-sample and total-sample (see figure 1). And then we used the T-test and found that at the 0.95 level, the difference of these two population is not significantly different. \( L_{\text{[OIII]}} \) is directly adopted from table 1 in Zakamsa et al. (2003). Using the \( L_{\text{[OIII]}} \) criterion of \( 3 \times 10^8 L_\odot \) (the logarithm is \( \sim 8.477 \)), which corresponds to the intrinsic absolute magnitudes \( M_B < -23 \) (Zakamsa et al. 2003), 20 objects can be classified as type II quasars. Fig. 1 shows a sample fitting for SDSS J150117.96+545518.2 with \( S/N=20.5 \). The final results are presented in table 1. All the fittings for 33 type II AGNs are appended in the appendix.

After subtracting the synthetic stellar components and the AGNs continuum, we obtain the clean pure emission-line spectra as shown in the top panel of figure 2, where we can analysis the pure emission-line profiles in detail by using the multi-component spectral fitting task SPECFIT (Kriss 1994) in the IRAF-STSDAS package. Because of the asymmetry of profiles of [O III] \( \lambda4959, 5007 \) lines, two sets of two-gaussian profiles are used in order to remove properly the asymmetric blue/red wings of [O III] line. We take the same linewidth for each component, and fix the flux ratio of [O III] \( \lambda4959 \) to [O III] \( \lambda5007 \) to be 1:3. For three objects, we can’t fit the [O III] lines for their irregular [O III] lines (see table 1). For the [O II] \( \lambda\lambda3727, 3729 \) lines, we use two-gaussian profiles and fix their wavelength separation to the laboratory value, the ratio of the line intensities is allowed to vary during the fitting. The decomposition for [O II] lines is more difficult because of relatively low \( S/N \) and that the expected line widths are comparable to the pair separation (2.4 Å). We do not fit [S II] \( \lambda\lambda6716, 6731 \) for our larger redshifts of our sample. For more details, please refer to Bian, Yuan & Zhao (2005, 2006). Our sample fitting for SDSS J150117.96+545518.2 is showed in figure 3.

3 RESULTS AND DISCUSSION

3.1 The uncertainties of stellar velocity dispersion (\( \sigma_v \)) and gaseous velocity dispersion (\( \sigma_g \))

The derived stellar velocity dispersion was corrected by the instrumental resolutions of both the SDSS spectra and the STELIB library. Cid Fernandes et al. (2004a) have used their stellar population synthesis method to study a sample of 79 nearby galaxies observable from the southern hemisphere, of which 65 are Seyfert 2 galaxies. The \( S/N \) in the \( S/N \) window varies between 10 and 67. They compared their \( \sigma_v \) with values from the literature and found the agreement is good. And they estimated that the uncertainty in \( \sigma_v \) is typically about 20 km s\(^{-1}\). Recently, Cid Fernandes et al. (2005) apply their synthesis method to a larger sample of 50362 galaxies from the SDSS Data Release 2 (DR2). Their derived \( \sigma_v \) is consistent very well with that of the MPA/JHU group (Kauffmann et al. 2003). The median of the difference between the two estimates is just 9 km s\(^{-1}\). We have carefully checked our synthesis fitting result one by one and picked out 33 type II AGNs that are well fitted and the stellar velocity dispersion \( \sigma_v \) are reliably derived. The spectral \( S/N \) for these objects are in the range of 5 to 21.5, most of which are larger than 10, thus the typical uncertainty in \( \sigma_v \) should be around 20 km s\(^{-1}\).

Recent, Greene & Ho (2006a, 2006b) used the direct-fitting method (Barth et al. 2002) to study the the systematic biases of \( \sigma_v \) form different regions around Ca II triplet, Mg II triplet, and Ca II+K stellar absorption features, which are introduced by both template mismatch and contamination from AGNs. They argue that the Ca II triplet provides the most reliable measurements of \( \sigma_v \) and there is a systematic offset between \( \sigma_CaK \) and \( \sigma_v \) derived from other spectral regions. For our higher-redshift sample and the SDSS wavelength coverage 3800-9200 Å, it is impossible to measure \( \sigma_v \) from Ca II triplet. Therefore, for higher-redshift type II AGNs, new observation around Ca II triplet is necessary in the future. Here we used the following formula to obtain the corrected velocity dispersion \( \sigma_v^* \) (Greene & Ho 2006b).

\[
\sigma_v^* = (1.40 \pm 0.04)\sigma_v - (71 \pm 5).
\]

For three objects, \( \sigma_v \) is near the instrumental resolution and the corrected \( \sigma_v^* \) is unreliable. These objects are omitted in our next analysis, which are denoted as \( \dagger \) in table 1.

The gaseous velocity dispersion \( \sigma_g \) is obtained from full width half maximum (FWHM) of emission lines by assuming the Gaussian profile: \( \sigma_{\text{FWHM}} = \sigma_{\text{FWHM}([\text{OII}]/2.35} \) and \( \sigma_{\text{FWHM}([\text{OIII}]/2.35. \) Considering the SDSS spectrum resolution, the intrinsic \( \sigma_v \) derived from FWHM([O III]) may be instrumentally broadened. The intrinsic \( \sigma_v \) can be approximated by \( \sigma_v = (\sigma_{\text{FWHM}} - (\sigma_{\text{FWHM}}(1+z)^2)^{1/2}) \), where \( z \) is the redshift. For the spectra from SDSS, the mean values of \( \sigma_{\text{FWHM}} \) are 74 km s\(^{-1}\) (the logarithm is 1.87 dex) for [O II], and 60 km s\(^{-1}\) (the logarithm is 1.78 dex) for [O III] (Greene & Ho 2005), respectively. The results of \( \sigma_g \) are listed in table 1 (Columns 7 and Columns 8). After removing the effect of instrumental broadening, some objects become unresolved (see table 1). Measurements of \( \sigma_g \) below the resolution limit (74 and 60 km s\(^{-1}\) for [O II] and [O III], respectively) are not reliable. The error of \( \sigma_g \) is derived from the error of the linewidth. For the linewidth, the typical error is about 10 per cent. However, the systematic effects are neglected, e.g., the uncertainties of the continuum subtraction, and component decomposition (Bian, Yuan & Zhao 2005).

3.2 The SMBHs masses and Eddington ratios in type II quasars

Using the reverberation mapping method or the empirical size-luminosity relation, it is impossible to estimate the SMBHs masses in type II quasars for the lack of emission line from BLRs. Here we use the formulae to derive the SMBHs masses in type II quasars from stellar velocity dispersion \( \sigma_v \) (Tremaine et al. 2002), which is \( M_{\text{BH}}(M_\odot) = 10^{8.13}(\sigma_v/(200 \text{ km s}^{-1}))^{1.62} \).
We also calculate the Eddington ratio, $L_{\text{bol}}/L_{\text{Edd}}$. We use [O III] luminosity as a surrogate for the AGN luminosity (Heckman et al., 2004; Greene & Ho 2005), $L_{\text{bol}} = 3500L_{\text{OIII}}$, to calculate the bolometric luminosity $L_{\text{bol}}$, and $L_{\text{Edd}} = 1.26 \times 10^{48}M_{\odot} / M_{\odot}$ ergs s$^{-1}$. The results of SMBHs masses and Eddington ratios in type II AGNs are also presented in table 1 (Columns 12 and 13). We also calculated the SMBH masses and Eddington ratios for the lower-redshifts type II AGNs at 0.02 < z < 0.3 presented by Kauffmann et al. (2003). For the typical uncertainties of 20 km s$^{-1}$ for $\sigma_c = 200$ km s$^{-1}$, the errors of $\log \sigma_c$ would be about 0.05 dex, corresponding 0.17 dex for $\log M_{\text{BH}}$, and almost the same for $L_{\text{bol}}/L_{\text{Edd}}$ (Bian, Yuan, & Zhao 2005). Here we didn’t consider the cosmology evolution of $M_{\text{BH}} - \sigma_c$ relation (e.g. Woo et al. 2006), which is a question open to debate.

In figure 4, we compared the distribution of SMBH masses and Eddington ratios in the lower-redshifts sample and the higher-redshifts sample. It is found that the type II AGNs at higher-redshifts have higher SMBHs masses and higher Eddington ratios.

It is well known that the Eddington ratio is an important parameter to describe the accretion process in AGNs. The [O III] luminosity is usually used as a surrogate for the AGN luminosity (Heckman et al. 2004 and the reference therein). In figure 5, we plot the [O III] luminosity versus the SMBH masses. Using a least-squares regression, we derive the correlation between $M_{\text{BH}}$ and $L_{\text{OIII}}$ to be: $\log(L_{\text{OIII}} / L_\odot) = (6.83 \pm 0.05) + (0.22 \pm 0.08) \log(M_{\text{BH}} / M_\odot)$. The correlation coefficient R is 0.45, with a probability of $P = 0.012$ for rejecting the null hypothesis of no correlation. However, no correlation is found between the [O III] luminosity and the accretion rate. From the peptonization model, the strength of [O III] is controlled by the NLRs covering factor, its density, and ionization parameter (e.g. Baskin & LaRo 2005). The relation between the [O III] luminosity and the AGN bolometric luminosity is still a question to debate.

### 3.3 The $\sigma_y - \sigma_c$ relation

The existence of a good correlation between stellar velocity dispersion ($\sigma_c$) and ionized gas velocity dispersion ($\sigma_y$) (e.g. Nelson & Whittle 1996) suggests that the gaseous kinematics of NLRs in Seyfert galaxies are primarily dominated by the bulge gravitational potential, which is further confirmed by Nelson & Whittle (1996). Most recently, Greene & Ho (2005) have investigated a large and homogenous sample of lower-redshift (0.02 < z < 0.3) Type II AGNs from the SDSS, and found that $\sigma_y$ traces $\sigma_c$. Though the gas kinematics of NLRs are governed by the gravitational potential of the bulges, they also find that the accretion rate plays an important secondary role.

Following Greene & Ho (2005), we study the $\sigma_y - \sigma_c$ relation for 33 Type II AGNs at redshifts 0.3 < z < 0.83 after measuring the gas velocity dispersion ($\sigma_y$) from the narrow emission lines from NLRs, and the stellar velocity dispersion ($\sigma_c$) from the Ca H+K, G-band absorption feature, which is shown in figure 2. It is obvious that, the line widths of the core component of [O III] and [O II] can approximately trace the stellar velocity dispersion, although with a considerable scatter (see figure 6). We confirm that the higher-redshift narrow-line AGNs follow the same trend as the lower-redshift ones, where the gas kinematics in NLRs is dominated by gravitational potential of the bulge and the velocity dispersion in the gas and stars are comparable. In order to qualify the comparison between $\sigma_c$ and $\sigma_y$, we calculate the distribution of $\sigma_y / \sigma_c$. The value is 1.24 ± 0.76 for the core component of [O III] line, 1.20 ± 0.96 for the [O II] line, which suggest that $\sigma_y$ of the core component of [O III] and [O II] lines can trace $\sigma_c$ within 0.06 and 0.08 dex in the logarhm of $\sigma_c$, respectively, and that the high-ionization [O III] line traces $\sigma_c$ as well as the low-ionization [O II] line. If we use the line width of $\sigma_c$ for the sample of Seyfert galaxies (Nelson & Whittle 1996), the value is 1.15 ± 0.68, suggesting that $\sigma_y$ of the [O III] line can trace $\sigma_c$ within 0.06 dex in the logarithm of $\sigma_c$. Our results are thus consistent with theirs.

In order to find the secondary effect of the line broadening in gas lines from NLRs for our higher-redshift narrow-line AGNs, we study the relation between the deviation of $\sigma_y$ from $\sigma_c$ ($\Delta \sigma = \text{log} \sigma_y - \text{log} \sigma_c$) and the Eddington ratio ($L_{\text{bol}}/L_{\text{Edd}}$) (Greene & Ho 2005). Using the least-squares regression, we find a median strong correlation between these two dimensionless parameters. For the [O III] line, the relation is: $\Delta \sigma = (0.11 \pm 0.04) + (0.22 \pm 0.05) \log(L_{\text{bol}} / L_{\text{Edd}})$. The Spearman rank correlation coefficient R is 0.77, with a probability of $P < 10^{-4}$ for rejecting the null hypothesis of no correlation. For the [O II] line, the relation is: $\Delta \sigma = (0.09 \pm 0.04) + (0.27 \pm 0.04) \log(L_{\text{bol}} / L_{\text{Edd}})$. These results confirm that the nuclei accretion process and/or nuclei SMBHs would effect the line width of gas lines from NLRs, although the primary driver is from the gravitational potential of the bulge.

### 4 CONCLUSION

The stellar population synthesis code is used to model the stellar contribution for a sample of 209 type II AGNs at redshifts 0.3 < z < 0.83 from SDSS. According to the $L_{\text{OIII}}$ criterion of $3 \times 10^8$ L$_\odot$, 20 of which can be classified as type II quasars. The main conclusions can be summarized as follows.

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The reliable $\sigma_*$ are measured for 33 type II AGNs with significant stellar absorption features. We used the formula of Greene & Ho to obtain the corrected stellar velocity dispersions ($\sigma_c^*$). And SMBHs masses are calculated from the $M_{BH} - \sigma_c^*$ relation. A median strong relation between the [O III] luminosity and the SMBH mass is found, no correlation between the [O III] luminosity and the Eddington ratio.

The gas velocity dispersion ($\sigma_g$) in NLRs is measured using three sets of two-gaussian profiles to fit [O III] $\lambda\lambda4959, 5007$ and [O II] $\lambda\lambda3727, 3729$) in these 33 stellar-light subtracted spectra. We find that $\sigma_g$ can trace $\sigma_c^*$ with considerable scatter, which confirms that the gaseous kinematics of NLRs in these type II quasars are primarily dominated by the gravitational potential of the bulge.

The distribution of $<\sigma_g/\sigma_c^*>$ is $1.24 \pm 0.76$ for the core [O III] line and $1.20 \pm 0.96$ for the [O II] line, which suggests that $\sigma_g$ can trace $\sigma_c^*$ within about 0.1 dex in the logarithm of $\sigma_c^*$. The deviation of $\sigma_g$ from $\sigma_c^*$ is correlated with the Eddington ratio.

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