# The broad wing of the [O III] $\lambda 5007$ emission line in active galactic nuclei $^*$

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Abstract We use a sample of type 2 active galactic nuclei (AGNs) from SDSS DR7 in which the [O III]  $\lambda$ 5007 emission line can be modeled by two Gaussian components, a broad wing plus a narrow core, to investigate the origin of the broad wing and the connection between the velocity shift of the broad wing and the physical parameters of AGNs, as well as their host galaxies. We find that the flux of the wing components is statistically roughly equal to that of the core components. However, the velocity shift of the wing component has only weak, if any, correlations with the physical properties of AGNs and the host galaxies, such as bolometric luminosity, the Eddington ratio, the mass of supermassive black holes, D4000, H $\delta_A$  or stellar mass. Comparing the velocity shift from our type 2 AGN sample to that from the type 1 sample in Zhang et al., we suggest that the [O III] broad wing originates from outflow.

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

## **1 INTRODUCTION**

Active galactic nucleus (AGN) feedback now appears to be a crucial process in galaxy formation and evolution. It is well known that the tight correlation between nuclear black hole mass ( $M_{\rm BH}$ ) and bulge stellar velocity dispersion (i.e., the  $M_{\rm BH}$  -  $\sigma_*$  relation; Ferrarese & Merritt 2000; Gebhardt et al. 2000; Tremaine et al. 2002) is compelling evidence for a close connection between the evolution of supermassive black holes and their host galaxies. AGN feedback is the most likely explanation for this relation (e.g., Silk & Rees 1998; Fabian 1999). Hopkins et al. (2006) also indicate the importance of feedback in the evolutionary model for starbursts, AGN activity and spheroidal galaxies. This feedback can terminate star formation in the host galaxy and cease gas accretion onto the nuclear black hole, in the form of radiation, winds, jets and outflows.

The various emission lines from the narrow-line region (NLR) in an AGN are ideally suited to study its central region, as well as the interaction between the central engine and its host galaxy.

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Unlike broad-line regions (BLRs), these NLRs are spatially resolvable, at least for nearby galaxies. It is generally believed that the narrow emission lines are produced by clouds illuminated by the central AGN, and the kinematics of the NLR clouds are mainly dominated by gravitational potential of the bulge (e.g., Whittle 1992; Nelson & Whittle 1996). Since the NLR is related to various factors such as the energy input from the central engine, the structure of the AGN, radio jets, star formation etc, it is important for a number of key questions related to AGN phenomena.

The [O III]  $\lambda\lambda4959$ , 5007 emission line pair is commonly used to study the properties of NLRs. It is usually the strongest narrow line in AGNs in the optical band and it is cleanly isolated from other emission and absorption features in the optical spectrum. The line profile of [O III] doublets in low-redshift AGNs is usually asymmetric. In most cases, there is a sharper fall-off to the red than to the blue, and the redshift of [O III] is negative compared to the systematic velocity derived from different indicators, such as the low-ionization lines ([N II], [S II]), or stellar absorption lines (Heckman et al. 1981 and subsequent researches). This asymmetric feature of the [O III] line has been suggested to be an indicator of outflows in Seyfert 1s and 2s (Heckman et al. 1981; Whittle et al. 1988; Colbert et al. 1996; Crenshaw et al. 2010), narrow line Seyfert 1 galaxies (Bian et al. 2005; Komossa et al. 2008), type 1 quasars (Heckman et al. 1984; Boroson 2005) and narrow line radio galaxies (Holt et al. 2008).

It is now believed that a broad blue wing in addition to the main narrow component is ubiquitous in [O III] emission. Many previous studies suggest that this blue wing is contributed by AGN outflows. They also attempt to correlate the parameters of lines, such as the [O III] blueshift and/or the [O III] line width, with the physical properties of AGNs (Zamanov et al. 2002; Aoki et al. 2005; Boroson 2005; Bian et al. 2005; Komossa et al. 2008). Based on homogeneous samples of radioquiet Seyfert 1 galaxies and QSOs selected from the Sloan Digital Sky Survey (SDSS), Zhang et al. (2011) find that the blueshift of [O III] has only weak correlations with fundamental AGN parameters, such as the nuclear continuum luminosity at 5100 Å ( $L_{5100}$ ), black hole mass ( $M_{\rm BH}$ ), and the Eddington ratio ( $L_{\rm bol}/L_{\rm Edd}$ ). Alexander & Hickox (2012) mentioned that statistically, the width and luminosity of the blue wing increase with [O III] luminosity, but are independent of radio loudness, indicating that the outflows are driven by AGN radiation rather than relativistic jets. Zhang et al. (2008) found that Seyfert 1s have lower [N II]/H $\alpha$  ratios than Seyfert 2s and the location of Seyfert 1s on the BPT diagram varies with extinction of broad lines, suggesting that the inner dense NLR is obscured by a dusty torus. The [O III] blue wing might originate in the inner dense NLR (Zhang et al. 2013). Stern & Laor (2013) revisit the location of type 1 and type 2 AGNs on the BPT diagrams, finding a similar result as Zhang et al. (2008) — type 1 AGNs are offset to lower [S II]/H $\alpha$ and [N II]/H $\alpha$  ratios. However, they conclude that this offset between type 1 and type 2 AGNs is a selection effect rather than dust extinction.

In this paper, we will explore the asymmetric behavior of [O III]  $\lambda\lambda4959,5007$  lines in more detail, studying the origin of [O III] asymmetry. In Section 2, we describe the sample selection and data analysis. We show the results in Section 3. In Section 4, the origin of the broad wing is discussed. Our conclusions are given in Section 5. Throughout this paper, a cosmology with  $H_0 = 70 \text{ km s}^{-1} \text{ Mpc}^{-1}$ ,  $\Omega_{\rm m} = 0.3$  and  $\Omega_{\Lambda} = 0.7$  is adopted.

## 2 SAMPLE AND DATA ANALYSIS

#### 2.1 The Sample

We begin with the galaxy sample from the SDSS (York et al. 2000) seventh data release (DR7; Abazajian et al. 2009) and select type 2 active galaxies based on the widely used BPT diagram (Baldwin et al. 1981). The SDSS DR7 spectroscopic galaxy catalog contains ~ 930 000 spectra taken through 3" diameter fibers in the primary redshift range  $0 \leq z \leq 0.3$ . Flux and equivalent width (EQW) of narrow emission lines (e.g., H $\alpha$ , [N II]  $\lambda$ 6583, [O III]  $\lambda$ 5007, H $\beta$ ) as well as line

indices D4000,  $H\delta_A$  and stellar mass have been publicly available since 2008 in the MPA/JHU catalog<sup>1</sup>.

The criteria used to select the sample of type 2 AGNs used in our analysis are the following:

- (1) Redshift between  $0.01 \le z \le 0.3$  and specPrimary = 1. The lower redshift limit of 0.01 is applied to avoid the influence of peculiar velocity. SpecPrimary = 1 deletes repeated observations from the sample.
- (2)  $\log([O \text{ III}]/\text{H}\beta) > 0.61/[\log([N \text{ II}]/\text{H}\alpha) 0.47] + 1.19$  (the solid curve in figure 2 from Kauffmann et al. 2003), or  $\log([N \text{ II}]/\text{H}\alpha) \ge 0.47$ . For those objects with H $\alpha$ , [N II], [O III], and H $\beta$  emission lines detected with signal-to-noise (S/N) ratio > 3, we separate type 2 AGNs from other sources using the emission line ratio diagnostics.
- (3) The EQW of the [O III] \u03c45007 emission line is smaller than -5 (negative EQW means emission) and the median S/N per pixel, in the range of rest-frame wavelength of 4880–4920 \u03c4 and 5030–5070 \u03c4 (the continuum around [O III]), is greater than 15. The requirement of high spectral quality around the [O III] region ensures reliable analysis of the line profile.

We refer to this sample hereafter as the "parent sample." It contains 9389 type 2 AGNs. Other parameters that could be used in this paper, such as stellar mass ( $M_*$ ), absorption line indices (D4000 and H $\delta_A$ ) and stellar velocity dispersion ( $V_{disp}$ ), are also provided in the MPA/JHU catalog.

#### 2.2 Fitting the Stellar Continuum

The aim of this study is to use the [O III] emission line to probe outflows in the NLR. In order to get pure emission line spectra, we need to model the stellar continuum of each galaxy. As described in Tremonti et al. (2004) and Brinchmann et al. (2004), the continua and absorption lines of each galaxy are fitted by a stellar population. The basic assumption is that any galaxy's star formation history can be approximated by a sum of discrete bursts. The library of template spectra is composed of single stellar population models that are generated using a preliminary version of the population synthesis code of Charlot & Bruzual (2014), including models of 10 different ages (0.005, 0.025, 0.1, 0.2, 0.6, 0.9, 1.4, 2.5, 5 and 10 Gyr) and four metallicities (0.004, 0.008, 0.017 and 0.04). For each metallicity, the ten template spectra with different ages are convolved to the measured stellar velocity dispersion of the SDSS galaxy. The best-fitting model spectrum is constructed from a non-negative linear combination of the ten template spectra, with dust attenuation modeled as an additional free parameter. The metallicity that yields the minimum  $\chi^2$  is selected as the final best fit. The fitting results can be found on the SDSS-MPA website.

#### 2.3 Fitting the Emission Lines

After subtracting the stellar continuum model, we use the following simple method to fit [O III]  $\lambda\lambda 4959$ , 5007 emission lines. First, we only use one Gaussian to model each [O III] line (hereafter the single-Gaussian model), and [O III]  $\lambda 4959$  is forced to have the same profile and shift as [O III]  $\lambda 5007$ . We use the galaxy redshift from the SDSS pipeline to define the rest frame. We also decompose each [O III] line into two Gaussians (hereafter the double-Gaussian model), a narrow core ([O III]\_{4959}^{\rm NC} and [O III]\_{5007}^{\rm NC}) and a broad wing ([O III]\_{4959}^{\rm BW} and [O III]\_{5007}^{\rm BW}). Each component of [O III]  $\lambda 4959$  is tied to the relevant component of [O III]  $\lambda 5007$  in the same way as that in the single-Gaussian model. The line center is limited to be in the range of 4980–5050 Å. We compare the reduced  $\chi^2$  of the single-Gaussian and double-Gaussian model, and use an F-test (Lupton, 1993, chap. 12.1) to calculate how significantly the fit is improved by the double-Gaussian model.

Figure 1 shows the probability level ( $\sigma_{\rm P}$ ) that the double-Gaussian model can improve the fit of emission lines, as a function of the improvement of  $\chi^2$ , which is defined as  $(\chi^2_{\rm one} - \chi^2_{\rm two})/\chi^2_{\rm one}$ .  $\chi^2_{\rm one}$ 

<sup>&</sup>lt;sup>1</sup> The raw data files from this catalog can be downloaded at *http://www.mpa-garching.mpg.de/SDSS/DR7/*.



**Fig.1** The probability level  $(\sigma_P)$  of the improvement in the fit of emission lines. We select the sources up the horizontal dashed line as our sample.

is the reduced  $\chi^2$  of the single-Gaussian model and  $\chi^2_{two}$  is the reduced  $\chi^2$  of the double Gaussian model. We select the 1630 sources up the horizontal dashed line as our sample for studying the outflow. These galaxies require two Gaussians at a significance greater than  $8\sigma$ , with  $\chi^2$  improvement greater than  $\sim 65\%$ .

## **3 RESULTS**

With the double-Gaussian model fitting of the 1630 sources in the sample, we find that the velocity shifts of the core component,  $V_{\text{off}}^{\text{core}} = (\lambda_{\text{core}} - \lambda_0)/\lambda_0 \times c$ , have a Gaussian distribution over a range of  $-200 \sim 200 \text{ km s}^{-1}$ , with a median value at 8 km s<sup>-1</sup> and 68% of the total probability is distributed over the range  $-37 \sim 53 \text{ km s}^{-1}$ . Here  $\lambda_{\text{core}}$  is the central wavelength of the core component,  $\lambda_0 = 5006.84$  is the rest-frame line center of [O III] in air and c is the speed of light. The distribution of velocity shifts of the wing component strongly deviates from Gaussian with a median shift of  $-72 \text{ km s}^{-1}$ . We note that the pipeline redshift is determined from both the emission lines and the continuum. If the emission lines are blueshifted, then the pipeline redshifts tend to be underestimated. Here we re-determine the systematic redshift from the continuum and absorption lines: starting from the stellar continuum model given in Section 2.2, we iteratively increase/decrease the systematic velocity by 5 km s<sup>-1</sup> and re-calculate a  $\chi^2$  value. The redshift of the absorption line is determined by the case with the lowest  $\chi^2$  value. In the following section, we use the redshift of this absorption line to define the rest-frame. Figure 2 shows one example of the two component fit, where black is the observed emission line spectrum, the broad wing and the narrow core are shown in blue and red, respectively and the best fit model is over-plotted in green.

#### 3.1 Correlation between Wing and Core Flux

In Figure 3, we show the correlation between the fluxes of the wing  $(F_{\rm wing})$  and core  $(F_{\rm core})$  of the [O III]  $\lambda$ 5007 emission line for both type 1 (red pluses) and type 2 (black pluses) AGN samples. The type 1 AGN sample contains 383 objects from Zhang et al. (2011) with a redshift range of  $0.01 \le z \le 0.3$ . The green line,  $\log F_{\rm wing} = (0.792 \pm 0.070) \log F_{\rm core} - (3.112 \pm 1.016)$ , is the best linear least-squares fit for type 1 AGNs with a Spearman rank-order correlation coefficient  $(r_{\rm S})$  of 0.663, while the blue line,  $\log F_{\rm wing} = (0.724 \pm 0.035) \log F_{\rm core} - (3.964 \pm 0.496)$ , is



**Fig. 2** An example of a double Gaussian fit. For each [O III] emission line, two Gaussian components are used. The red represents the core component, and the blue one is the underlying broad wing. The best fit model is shown in green.



**Fig. 3** Correlation between the fluxes of broad wing and narrow core of the [O III]  $\lambda$ 5007 emission line in type 1 (*red*) and type 2 (*black*) AGNs. The Spearman rank-order correlation coefficients ( $r_s$ ) are 0.663 (0.701) for type 1 (type 2) AGNs. The best linear least-squares approximation is shown. The green line is for type 1s and the blue long dashed line is for type 2s. The gray short dashed line is the x = y line.

the fit for type 2 AGNs, with  $r_{\rm S} = 0.701$ . Zhang et al. (2011) found that, on average, the core component comprises 54% of the total emission, which is consistent with a 52% contribution of the core component in our type 2 sample. A detailed explanation of this strong correlation between the fluxes of core and wing components in both type 1 and type 2 AGNs is beyond the scope of the current paper; we will build a model to understand this correlation in a following paper.

## **3.2** How $V_{\text{off}}^{\text{wing}}$ Depends on the Properties of Galaxies

Since the blue asymmetry of the [O III] profile generally suggests the existence of an outflow, we explore whether the shift in the broad wing is connected with the strength of AGN activity and star formation which are the primary drivers of the outflow. We estimate the bolometric luminosity of the AGN as  $L_{\rm bol} \approx 600 L_{\rm [O III]}$  (Kauffmann & Heckman 2009).  $L_{\rm [O III]}$  is the total luminosity of the wing and core with dust extinction from Balmer decrement, and the correlation in this section is independent of which [O III] luminosity we use,  $L_{\rm [O III]}^{\rm wing}$ ,  $L_{\rm [O III]}^{\rm core}$  or  $L_{\rm [O III]}^{\rm wing} + L_{\rm [O III]}^{\rm core}$ . The Eddington ratio is defined as  $\lambda = L_{\rm bol}/L_{\rm Edd}$ , where  $L_{\rm Edd} \equiv 1.26 \times 10^{38} (M_{\rm BH}/M_{\odot})$  erg s<sup>-1</sup>. The mass of the central black hole is estimated from the famous  $M_{\rm BH}$  -  $\sigma_*$  relation (Ferrarese & Merritt 2000; Gebhardt et al. 2000) with the form  $\log(M_{\rm BH}/M_{\odot}) = 8.13 + 4.02 \log(\sigma_*/200)$  (Tremaine et al. 2002), where  $\sigma_*$  is the stellar velocity dispersion.

Figure 4 shows the velocity shift of the wing component  $(V_{off}^{wing})$  as a function of  $L_{bol}$ ,  $\lambda$ , mass of supermassive black holes  $(M_{BH})$ , D4000,  $H\delta_A$  and stellar mass  $(M_*)$ . The stellar mass  $(M_*)$  and absorption line indices (D4000 and  $H\delta_A$ ) are provided in the MPA/JHU catalog. The red lines are the median (see online version). The correlation results are listed in Table 1, where  $r_S$  is the Spearman rank-order correlation coefficient and  $P_{null}$  is the probability for the null hypothesis of no correlation. The high significance of  $P_{null}$  is due to the large number of sources in our sample. In summary, we have found no distinct correlation between  $V_{off}^{wing}$  and galaxy properties. Outflow is driven by both AGN and star formation activity. However, the contribution of AGN and star formation activity to the outflow varies from object to object. This leads to a lack of correlation in Figure 4. This result is consistent with that in Komossa et al. (2008) and Zhang et al. (2011).

Table 1 Correlation Results between  $V_{\text{off}}^{\text{wing}}$  and Galaxy Properties

Correlation	$L_{\rm bol}$	λ	$M_{\rm BH}$	D4000	${ m H}\delta_{ m A}$	$M_*$
$r_{ m S}$ $P_{ m null}$	-0.184 $8.9 \times 10^{-13}$	$0.010 \\ 6.8 \times 10^{-1}$	-0.083 $1.3 \times 10^{-3}$	$0.097 \\ 1.9 \times 10^{-4}$	-0.204 $1.9 \times 10^{-15}$	-0.083 $1.3 \times 10^{-3}$

#### 3.3 Comparison with Type 1 AGNs

In the standard AGN unified scheme, type 1 and type 2 AGNs are intrinsically the same objects. As a result of the obscuration of the torus, the radiation originating from the accretion disk will mostly push materials out along the rotation axis of the accretion disk. If the blue wing of [O III] is triggered by outflows, we should observe a faster velocity in type 1 than in type 2 AGNs due to the inclination effect. In order to avoid any effect of evolution and make a fair comparison between type 1 and type 2 AGNs, we construct twin subsamples from the type 1 (Zhang et al. 2011) and type 2 AGNs by matching their redshifts with a tolerance of  $\Delta z = 0.004$ ; namely, the type 1 and type 2 subsamples have exactly the same redshift distribution; see the histograms in Figure 5. The black, blue and red lines show the redshift distributions for type 1 and type 2 AGNs, and the matched twin sample, respectively. Through this redshift match, each subsample contains 264 objects. Figures 6 and 7 show the distributions of velocity offset and line width of the [O III] wing and core components for the twin subsamples, and the median values are shown by vertical dashed lines, black for type 1 and blue for type 2 AGNs.

In Figure 6, we show the distributions of the velocity offset relative to the systematic velocity,  $V_{\rm off}^{\rm core}$  and  $V_{\rm off}^{\rm wing}$ . The systematic velocity is derived from the [S II] emission line for the type 1 sample and from stellar absorption lines for the type 2 sample. The median values of  $V_{\rm off}^{\rm core}$  are -11 km s<sup>-1</sup> and 6 km s<sup>-1</sup> for type 1 and type 2 subsamples, respectively and the median values of  $V_{\rm off}^{\rm wing}$  are -162 km s<sup>-1</sup> and -97 km s<sup>-1</sup> for type 1 and type 2 subsamples, respectively.



Fig. 4 Velocity shifts of the wing component relative to the systematic velocity  $V_{\text{off}}^{\text{wing}}$  versus  $L_{\text{bol}}$ ,  $\lambda$ ,  $M_{\text{BH}}$ , D4000,  $\text{H}\delta_{\text{A}}$  and  $M_*$ . Diamonds show the position of the median value in each bin.



**Fig. 5** Redshift distribution of type 1 (*black*) and type 2 (*blue*) AGN samples. The red histogram shows the redshift distribution of the twin sample (*color online*).

In Figure 7, we show the distributions of line width of the wing ( $\sigma_{\rm wing}$ ) and core ( $\sigma_{\rm core}$ ) components. The median values of  $\sigma_{\rm core}$  are 138 km s<sup>-1</sup> and 131 km s<sup>-1</sup> for type 1 and type 2 subsamples, respectively, and the median values of  $\sigma_{\rm wing}$  are 393 km s<sup>-1</sup> and 370 km s<sup>-1</sup> for type 1 and type 2 subsamples, respectively. Basically, there is no difference in  $\sigma_{\rm core}$  and  $\sigma_{\rm wing}$  between type 1 and type 2 AGNs.



**Fig. 6** Distributions of velocity offset relative to the systematic redshift for type 1 (*black*) and type 2 (*blue*) twin samples (*color online*). The left panel is for the core component, while the right panel is for the wing component. The median values are marked by the black vertical short dashed line for type 1s and the blue vertical long dashed line for type 2s.



**Fig.7** Distributions of the line width  $\sigma$  for type 1 (*black*) and type 2 (*blue*) twin samples (*color online*). The left panel is for the core component, while the right panel is for the wing component. The median values are marked by the black vertical short dashed line for type 1s and the blue vertical long dashed line for type 2s.

#### **4 ORIGIN OF THE BROAD WING**

In this section, we discuss the origin of the broad wing of [O III]  $\lambda\lambda4959, 5007$ , including its location and physical mechanism, based on the observational results in Section 3.

- (1) Location. We derive black hole mass  $(M_{\rm BH})$  from the  $M_{\rm BH}$   $\sigma_*$  relation. At the same time, if we assume that the region which generates the wing component is still dominated by the potential of a central supermassive black hole, we can estimate the location of the region  $(R_{\rm wing})$  where the wing comes from as  $R_{\rm wing} = G \frac{M_{\rm BH}}{f\Delta V^2}$ , where f is the scaling factor with a value of 3.85 (Collin et al. 2006) and  $\Delta V$  is the width of the emission line. We set  $\Delta V = \sigma_{\rm wing}$  and  $G = 6.67384 \times 10^{-11} \text{ m}^3 \text{ kg}^{-1} \text{ s}^{-2}$  is the gravitational constant. Finally, we get  $R_{\rm wing}$  with a median value of ten pc for both type 1 and type 2 subsamples. We stress that the value of  $R_{\rm wing}$  that we derive should be a lower limit since the region that the blue wing originates is not virialized.
- (2) **Physical mechanism.** In Section 3.3, we found that the wing component has a median of  $V_{\text{off}}^{\text{wing}} = -162 \ (-97) \text{ km s}^{-1}$  for the type 1 (type 2) subsample. If we assume that the velocity offset of the wing component originates from the outflows which blow out in a direction perpendicular to the accretion disk, we would expect  $V_{\text{off}}^{\text{wing}}$  (type 2) =  $V_{\text{off}}^{\text{wing}}$  (type 1) × cos  $\theta$ ,

where  $\theta$  is the opening angle of the torus, and  $V_{\text{off}}^{\text{wing}}$  (type 1) and  $V_{\text{off}}^{\text{wing}}$  (type 2) are median values of the velocity offset of the wing component for type 1 and type 2 AGNs, respectively. Applying  $V_{\text{off}}^{\text{wing}}$  (type 1) =  $-162 \text{ km s}^{-1}$  and  $V_{\text{off}}^{\text{wing}}$  (type 2) =  $-97 \text{ km s}^{-1}$ , we get  $\theta \sim 50^{\circ}$ . This result is consistent with that from the literature (e.g., Netzer 1987; Krolik et al. 1994).

In addition, we have found no distinct correlation between  $V_{\rm off}^{\rm wing}$  and galaxy properties (D4000,  $H\delta_A$ , stellar mass), as well as the physical properties of AGNs (bolometric luminosity, the Eddington ratio, black hole mass). This result is consistent with those of several previous studies (e.g., Komossa et al. 2008; Zhang et al. 2011). If we accept a scenario in which the low-velocity gas in the core component is dominated by the gravity of the bulge, but the wing is more strongly influenced by the outflow cloud of an active nucleus (e.g., Zamanov et al. 2002; Greene & Ho 2005), the terminal outflow velocity would depend on the origin of the outflow on the one hand, and the deceleration mechanism on the other hand. Komossa et al. (2008) discussed several possibilities to explain the acceleration and entrainment of the NLR outflow, including radiation pressure, entrainment in radio jets, thermal winds and high Eddington ratio. So, the launching velocity of the outflow cloud is determined by different acceleration mechanisms and/or different stages of the AGN activity. Meanwhile, NLR outflow is decelerated by the interstellar medium (ISM) of the host galaxy. A denser ISM results in more efficient deceleration, which implies lower velocity (Zhang et al. 2011). Both acceleration mechanisms and the column density of the NLR cloud would lead to different terminal velocities, thereby explaining the lack of correlation between the observed  $V_{\rm off}^{\rm wing}$  and the physical properties of AGNs.

## **5** CONCLUSIONS

We select a type 2 AGN sample from SDSS DR7. In this sample, two Gaussian components are required to model the [O III]  $\lambda$ 5007 emission line, a broad wing plus a narrow core. We measure the velocity shift (relative to the absorption lines), line width and flux of both components. Combining our type 2 AGN sample with a type 1 sample from Zhang et al. (2011), we find that

- (1) There is a tight correlation between the fluxes of wing and core components in both type 1 and type 2 samples. In both samples, the flux of the wing components is roughly equal to that of the core components.
- (2) In the unification scheme of AGNs, the type 1 and 2 AGNs are intrinsically the same; their different appearance is due to the fact that we observe them from different directions; a dusty torus blocks the continuum source and broad-line region in type 2 AGNs. The difference in the velocity shift of the broad wing between type 1 and type 2 AGNs is consistent with a picture in which the broad wing originates from outflows and the outflows blow out in a direction perpendicular to the accretion disk with a certain opening angle.
- (3) The velocity shift of the wing component has only weak, if any, correlations with the physical properties of AGNs (bolometric luminosity, the Eddington ratio and the mass of supermassive black holes) and the host galaxies (D4000,  $H\delta_A$  or stellar mass). We suggest the lack of correlation is due to the outflow being driven by both AGN and star formation activity. However, the contribution of AGN and star formation activity to the outflow varies from object to object. A future IFU survey, such as Mapping Nearby Galaxies at APO (MaNGA), will help us to understand AGNs and star formation, which is the primary driver of outflow in certain objects.

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