1. INTRODUCTION

Binary supermassive black holes (SMBHs) are possible outcomes of the hierarchical mergers of galaxies (e.g., Begelman et al. 1980; Milosavljević & Merritt 2001; Yu 2002). In one of the leading hypotheses, major mergers between galaxies are responsible for triggering nuclear starbursts and quasar activity (e.g., Hernquist 1989). Despite the success of the merger scenario in explaining much of the observed phenomenology of active galactic nuclei (AGNs) (e.g., Kauffmann & Haehnelt 2000; Volonteri et al. 2003; Wyithe & Loeb 2003; Hopkins et al. 2008; Shen 2009) and the cores of massive elliptical galaxies (e.g., Faber et al. 1997; Kormendy & Bender 2009), direct observational evidence for binary SMBHs is surprisingly scarce.

The fraction of binary quasars at separations of tens to hundreds of kpc (halo) scales, is \(\leq 0.1\%\) at 1 \(\leq z \leq 5\) (e.g., Hennawi et al. 2006, 2009; Myers et al. 2008). On kpc (galactic) scales there are only a handful of unambiguous low-redshift cases known, in which both active SMBHs are detected in X-rays (NGC 6240 and Mrk 463; Komossa et al. 2003; Bianchi et al. 2008), or in the radio (3C 75; Owen et al. 1985). On sub-kpc scales, only one case is known (0402+379; Rodriguez et al. 2006) of a pair of black holes (BHs) detected by VLBI with a projected separation of \(\sim 7\) pc. There are several possible reasons that binary SMBHs are so rare compared to the expectations from the merger scenario: they spend most of their time at separations far below kpc scales and hence are difficult to resolve spatially; one or both of the SMBHs are heavily obscured; both BHs are rarely active at the same time, and dynamical differences between a single BH and a binary BH are not readily discernable at cosmological distances.

Recently, Comerford et al. (2009b) conducted a systematic survey of type 2 AGNs in the DEEP2 galaxy sample at \(z \sim 0.6\) (Davis et al. 2003). They argue that 37 of the 107 AGNs in their sample are inspiralling binary SMBHs, based on significant velocity offsets between the narrow-line region (NLR) emission lines \([\text{OIII}]\lambda 4959,5007\) and the systemic redshift measured from stellar absorption features. In particular, two of these objects (one reported by Gerke et al. 2007) show double-peaked \([\text{OIII}]\) lines with velocity offsets of a few hundred km s\(^{-1}\) and spatial offsets of several kpc; they interpreted these as binary SMBHs when both BHs are active. Such double-peaked \([\text{OIII}]\) emission line features have also been seen in a few optically selected AGNs (e.g., Heckman et al. 1981; Zakamska et al. 2003; Zhou et al. 2004). One advantage of using spectroscopy to find binary SMBHs is that it is not limited by spatial resolution, as long as the separation is not so small that the NLRs are no longer discernible. On the other hand, such spectral features may be due to biconical outflows or disk rotation around a single SMBH (e.g., Axon et al. 1998; Veilleux et al. 2001; Crenshaw et al. 2009).

Here we focus on double-peaked narrow-line objects in which the associated line emitting gas is on scales of \(\sim 100\) pc to several kpc. Therefore in the binary SMBH scenario, our double-peaked sample would include objects whose two SMBHs along with their own NLR gas are still co-rotating in the galactic potential, well before forming a pc-scale binary under dynamical friction (e.g., Milosavljević & Merritt 2001). For double-peaked broad-line objects which may involve outflows or disks on \(\lesssim 1\) pc scales (see, e.g., Eracleous & Halpern 1994 and Strateva et al. 2003).

We have carried out a systematic search in the Sloan Digital Sky Survey (SDSS; York et al. 2000) spectroscopic database for emission line AGNs with double-peaked features or peculiar \([\text{OIII}]\) line shifts relative to the systemic redshift as measured from stellar absorption features. Here we report our initial
results on a sample of 167 type 2 AGNs with double-peaked [O III] emission lines. We describe our sample selection in Section 2; the statistical properties of the sample are presented in Section 3, and we discuss our results and conclude in Section 4. A cosmology with $\Omega_m = 0.3$, $\Omega_\Lambda = 0.7$, and $h = 0.7$ is assumed throughout.

2. DATA

2.1. The Sample

Our parent sample is the MPA-JHU SDSS DR7 galaxy sample drawn from the SDSS DR7 spectroscopic database (Abazajian et al. 2009); those include objects spectrally classified as galaxies by the specBS pipeline (Adelman-McCarthy et al. 2008) or quasars that are targeted as galaxies (Strauss et al. 2002; Eisenstein et al. 2001) and have redshifts $z < 0.7$. We adopt redshifts $z$ and stellar velocity dispersions $\sigma_*$ from the specBS pipeline. When unavailable from the pipeline, we measure $\sigma_*$ using the direct-fitting algorithm described in Greene & Ho (2006) and Ho et al. (2009); we have checked that this code gives results consistent with those of specBS. We have checked the accuracy of the redshift by refitting the stellar continuum with galaxy templates (Liu et al. 2009), as well as comparing multiple epoch spectra of the same objects. The quoted redshift faithfully traces the stellar absorption features (which we take as the systemic redshift), with typical statistical errors of a few km s$^{-1}$ and systematic errors of $\sim 10$ km s$^{-1}$. Additional spectral and photometric properties such as emission-line fluxes (determined from equivalent widths (EWs) and continuum fluxes), spectral indices, stellar masses, and concentration indices are taken from the MPA-JHU SDSS DR7 data product.

We select our AGN sample from this parent sample by the following criteria: (1) the rest-frame wavelength ranges [4700, 5100] Å and [4982, 5035] Å centered on the [O III] $\lambda 5007$ line have median signal-to-noise ratio (S/N) $> 5$ pixel$^{-1}$ and bad pixel fraction $< 30$%; (2) the [O III] $\lambda 5007$ line is detected at $> 5\sigma$ and has a rest-frame EW $> 4$ Å; 3) the line flux ratio [O III] $\lambda 5007$/H$\beta$ $> 3$ if $z > 0.33$, or the diagnostic line ratios [O II] $\lambda 5007$/H$\beta$ and [N II] $\lambda 6584$/H$\alpha$ lie above the theoretical upper limits for star-formation excitation from Kewley et al. (2001) on the BPT diagram (Baldwin et al. 1981) if $z < 0.33$. This procedure yields $\sim 14,300$ type 2 AGNs. We supplement this sample with $\sim 400$ type 2 quasars from Reyes et al. (2008) which are not included in the MPA-JHU data products. These additional type 2 quasars extend to somewhat higher redshifts ($z < 0.83$). Our final AGN sample includes 14,756 objects with high S/N and high spectral quality around the [O III] lines, suitable for the analysis that follows. The redshift distribution of this parent AGN sample is shown in Figure 1.

In many AGNs and starbursts, the narrow forbidden emission lines [O III] $\lambda\lambda 4959,5007$ are known to have peculiarities such as extended blue wings, velocity offsets from systemic redshifts, and complex line profiles (e.g. Heckman et al. 1981; Whittle 1985a; Zakamska et al. 2003; Zhou et al. 2006; Komossa et al. 2008). We here focus on a more dramatic subset—those with double-peaked [O III] emission lines. A complete analysis of the nature and statistical properties of other peculiar [O III] line characteristics will be presented elsewhere.

The identification of such double-peaked objects requires that both [O III] $\lambda 4959$ and [O III] $\lambda 5007$ are better fitted with two components rather than a single component. As the initial screening process we visually inspected the spectra of all the 14,756 AGNs and identified 167 objects with unambiguous double-peaked [O III] lines. We only include objects which have well-detected double peaks in both [O III] $\lambda 4959$ and [O III] $\lambda 5007$ with similar profiles; we do not include those with complex line profiles such as lumpy, winged, or multi-component features. We plot the redshift distribution of the double-peaked sample in Figure 1, and the SDSS images and spectra of three such examples in Figure 2. We list all the 167 double-peaked AGNs and their line measurements in Table 1.

We caution that there could be some double-peaked narrow-line objects in SDSS DR7 missed by our selection if the pipeline got the redshifts wrong because of the peculiar line profiles, although this fraction is likely to be no larger than a few percent.

We measured the line properties of these double-peaked objects as follows. The galaxy continuum was subtracted using the best-fit template constructed from a linear combination of instantaneous starburst models of Bruzual & Charlot (2003) with ten different ages, as described in Liu et al. (2009). In the 11 objects for which the stellar continuum is too weak for measuring $\sigma_*$ and for template fitting, a simple power-law model was used. The continuum-subtracted [O III] region ($\lambda\lambda 4930$–5040 Å) was fitted by a pair of Lorentzian functions convolved with the measured instrumental resolution of the spectra ($\sigma \sim 65$ km s$^{-1}$). The redshift and line width for each velocity component of [O III] $\lambda 4959$ and [O III] $\lambda 5007$ were forced to be the same. The flux ratio of [O III] $\lambda 5007$ to [O III] $\lambda 4959$ was allowed to vary (but we found it was always close to 3). In cases where H$\beta$ is measurable, we further fit a double-Lorentzian to the H$\beta$ region ($\lambda\lambda 4850$–4880 Å), where the positions of the centroids were allowed to vary, but the widths of the two H$\beta$ components were fixed to the best-fit values for the two [O III] components. We then repeated this

\[ \text{Figure 1. Redshift distribution of the parent AGN and double-peaked samples.} \]
fitting process with a double-Gaussian model, and took as the best fit the model which had the smaller reduced \( \chi^2 \) for each object. We visually inspected all the fits and verified that the line profiles are generally well reproduced by the model. For [O III], the typical statistical errors in the best-fit velocity difference between the two components \( v_{\text{off}} \), line fluxes, and FWHMs are \( \sim 5 \text{ km s}^{-1} \), \( \sim 5\% \), and \( \sim 10 \text{ km s}^{-1} \), but we caution that the actual uncertainties are likely to be larger. For H\( \beta \), the statistical errors are generally a few times larger because H\( \beta \) is weaker than [O III].

2.2. Selection Completeness

Our selection of double-peaked objects was done by eye and is by no means objective. To gain some sense of our
We generated mock spectra of double-peaked objects in the Hβ-[O III] region with random distributions of continuum S/N, EW, velocity offset, and FWHM of the two components of [O III]. We randomly assigned a Gaussian or Lorentzian profile to each line and broadened the spectrum using an instrumental Gaussian broadening of $\sigma = 65\text{ km s}^{-1}$. In this way we generated 2000 mock spectra of double-peaked objects and mixed them with 18,000 mock spectra of single-peaked objects with random spectral properties. We then visually inspected the 20,000 mock spectra and identified double-peaked objects in the same way as we did for the real sample. We show in Figure 3 the selection completeness as a function of median S/N, $v_{\text{off}}$, FWHM, total [O III] $\lambda 5007$ EW, and flux (EW) ratio between the two components $f_{\text{EW}}$. In general, the completeness increases with increasing $v_{\text{off}}$, [O III] $\lambda 5007$ EW, and $f_{\text{EW}}$, and decreases with increasing FWHM, as expected from the way our double-peaked objects are identified. As a result there is a selection bias against objects with small $v_{\text{off}}$ and large FWHM that we discuss later. In addition, we are very incomplete for objects with $v_{\text{off}} \lesssim 200\text{ km s}^{-1}$ partly due to the spectral resolution limit. On the other hand, we find that the false detection rate is very low (<2% of the double-peaked sample)—probably an advantage of visual inspection over automated algorithms. We note that the completeness estimated this way is not the absolute completeness, which depends on the actual underlying distributions of all relevant properties. Nevertheless, these completeness estimates are useful to correct for selection biases. For example, when other properties are fixed, double-peaked objects with larger EWs are easier to identify, by a relative amount that can be determined from our simulation results.

After accounting for the dependence of selection completeness on [O III] EW, we find tentative evidence that the fraction of double-peaked objects in the underlying AGN sample depends on [O III] $\lambda 5007$ luminosity ($L_{\text{[O III]}}$): it increases by a factor of $\sim 2$ from $L_{\text{[O III]}} \sim 10^{7.0}L_{\odot}$ to $L_{\text{[O III]}} \sim 10^{8.5}L_{\odot}$, and has no clear dependence on redshift in the range probed. In most cases, the two velocity components are redshifted and blueshifted with respect to the systemic redshift (except that in a few cases, one component is apparently coincident with the systemic velocity within the errors), and about half of them have more prominent redshifted components—a subset which may be more unusual since objects with outflows may tend to have more prominent blueshifted components (see below). In cases where Hβ is measurable, it also shows a double-peaked feature with a similar velocity offset as that of [O III]. Hereafter we use $v_{\text{off}}$ measured from [O III] in our analysis as it is more robust than that from Hβ. As illustrated in Figure 4(a), both velocity components have excitation diagnostic line ratios $H\beta/[\text{O III}]$ characteristic of AGNs. The FWHM of each velocity component is typically smaller than $v_{\text{off}}$ by a factor of $\sim 1.5$.

### 3. STATISTICAL PROPERTIES

#### 3.1. Host-galaxy Properties

Are there any characteristics of the host galaxies of the double-peaked objects that are different from ordinary AGNs? The double-peaked sample is not selected uniformly as we

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5 For instance, the object SDSS J000249.07+004504.8, with $v_{\text{off}} \sim 150\text{ km s}^{-1}$ reported in Comerford et al. (2009a) is not included in our sample based on the SDSS spectrum alone.

6 For objects with $z < 0.3$, the [N II] and Hα lines are visible; they appear double peaked as well, although the different components often are blended with one another.
Figure 4. NLR physical properties of the double-peaked components. Objects with stronger redshifted components are plotted as red open circles whereas those with stronger blueshifted components are plotted as blue plus signs. The Spearman correlation coefficient and the probability of null correlation are labeled in each plot for the whole (black), the stronger-blueshifted (blue), and the stronger-redshifted (red) samples, respectively. (a) Ionization parameter (indicated by the flux ratio between [O iii] λ5007 and Hβ) of the blueshifted component vs. that of the redshifted component. (b) Line width ratio of the double-peaked components vs. Balmer decrement (as a measure of reddening). (c) Electron density (inferred from the flux ratio between the [S ii] λλ6717,6731 doublet) of the blueshifted component vs. that of the redshifted component. 

Figure 5. Host-galaxy properties (stellar velocity dispersion $\sigma_*$, stellar mass $M_*$, spectral indices $D_n(4000)$ and HδA indicating the luminosity-weighted mean stellar age and the post-starburst fraction, and r-band concentration index $R_{90}/R_{50}$, $r$) of the double-peaked sample (red) compared to the control sample (black). The control sample is randomly drawn from the parent AGN sample to have identical redshift, [O iii] λ5007 EW and luminosity distributions as the double-peaked sample. We compare their host-galaxy properties, including stellar mass and velocity dispersion, SDSS colors, stellar population parameters $D_n(4000)$, and HδA (indicating the luminosity-weighted mean stellar age and the post-starburst fraction in the past $\sim$0.1–1 Gyr, respectively; e.g., Kauffmann et al. 2003), intrinsic extinction (estimated by the Balmer decrement), effective radius, concentration (characterized by, $R_{90, r}/R_{50, r}$, the ratio of radii that contain 90% and 50% of the $r$-band Petrosian flux), and inclination (estimated by the ratio between the major and minor isophotal axis). As shown in Figure 5, the double-peaked sample has systematically larger stellar velocity dispersions and masses, older mean stellar ages (and redder colors), smaller fractions of post-starburst populations in the past $\sim$0.1–1 Gyr, and higher concentrations than the control sample. The difference in the centroids of the two distributions are roughly half of the width of the distributions. Kolmogorov–Smirnov (KS) tests show that the probabilities that the two samples are drawn from the same distribution are $P_{KS} < 10^{-3}$. All other properties of the host galaxies we examined were indistinguishable with KS probabilities $P_{KS} > 10^{-1}$. We also match the double-peaked and the control samples with the FIRST (Becker et al. 1995; White et al. 1997) and ROSAT (Voges et al. 1999, 2000) surveys and find that they contain very similar fractions of matches with both surveys ($\sim$35% with FIRST and $\sim$2% with ROSAT). The subset that has a more prominent redshifted component is indistinguishable from the rest of the double-peaked sample in terms of the properties studied above.

3.2. Correlations Between Line Properties

There are several apparent correlations among the dynamical properties and the NLR physical conditions of the double-peaked sample. Figures 4(a) and (c) illustrate that the two velocity components have similar ionization parameters (as indicated by the diagnostic line ratio Hβ/[O iii]) and HδA, intrinsic extinction (estimated by the Balmer decrement), effective radius, concentration (characterized by, $R_{90, r}/R_{50, r}$, the ratio of radii that contain 90% and 50% of the r-band Petrosian flux), and inclination (estimated by the ratio between the major and minor isophotal axis). As shown in Figure 5, the double-peaked sample has systematically larger stellar velocity dispersions and masses, older mean stellar ages (and redder colors), smaller fractions of post-starburst populations in the past $\sim$0.1–1 Gyr, and higher concentrations than the control sample. The difference in the centroids of the two distributions are roughly half of the width of the distributions. Kolmogorov–Smirnov (KS) tests show that the probabilities that the two samples are drawn from the same distribution are $P_{KS} < 10^{-3}$. All other properties of the host galaxies we examined were indistinguishable with KS probabilities $P_{KS} > 10^{-1}$. We also match the double-peaked and the control samples with the FIRST (Becker et al. 1995; White et al. 1997) and ROSAT (Voges et al. 1999, 2000) surveys and find that they contain very similar fractions of matches with both surveys ($\sim$35% with FIRST and $\sim$2% with ROSAT). The subset that has a more prominent redshifted component is indistinguishable from the rest of the double-peaked sample in terms of the properties studied above.

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Figure 6. Dynamical properties of the double-peaked components. Objects with stronger redshifted components are plotted as red open circles whereas those with stronger blueshifted components are plotted as blue plus signs. The Spearman correlation coefficient and the probability of null correlation are labeled in each plot for the whole (black), the stronger-blueshifted (blue), and the stronger-redshifted (red) samples, respectively. (a)–(c) stellar velocity dispersion $\sigma^*$, FWHM of the blueshifted component, and FWHM of the redshifted component vs. velocity offset between the double-peaked components. (d) FWHM of the blueshifted component vs. that of the redshifted component. (e) Velocity-offset ratio of the double-peaked components vs. the flux ratio. (f) Velocity-offset ratio of the double-peaked components vs. the FWHM ratio.

(A color version of this figure is available in the online journal.)

FWHM corner, where the double-peaked feature is difficult to identify. However, our Monte Carlo simulations show no selection bias against objects with high $v_{\text{off}}$ and small FWHMs (Section 2.2). In particular, the correlation between $v_{\text{off}}$ and $\sigma^*$ suggests that the double-peaked line-emitting regions are on galactic scales where the galactic potential dominates the bulk kinematics. Furthermore, Figures 6(e) and (f) show that both the [O III] line flux ratio and the line width ratio of the two velocity components are anti-correlated with the ratio of their line-of-sight (LOS) velocity offsets relative to the systemic redshift (see also Wang et al. 2009), which most likely results from momentum conservation.

4. DISCUSSION

4.1. NLR Kinematics

The double-peaked feature may result from particular NLR geometries such as biconical outflows\(^7\) or rotating disks on kpc scales. In these scenarios, there is only one SMBH and the observed blueshifted and redshifted emission-line peaks arise from NLR gas moving toward and away from us. Certain nearby Seyfert galaxies known to have biconical outflows show double-peaked emission when spectra are taken over the whole galaxy. Such prototypical cases include NGC 1068 (e.g., Axon et al. 1998) and NGC 3079 (e.g., Duric & Seaquist 1988). It is very likely that there are some such sources in our sample. Several objects in our sample show clear galactic disks in their SDSS images. Here the correlation between line width and velocity shift naturally arises, as the bulge gravitational potential well influences the motion of NLR gas. The correlation between the diagnostic line ratio [O III]/H$\beta$ of the two components shown in Figure 4(a) may be explained if the NLR gas of both velocity components is ionized by a single SMBH.

Can all the objects in our double-peaked sample be ascribed to NLR geometry? Outflows and inflows of NLR gas have long been invoked to explain several commonly observed features in NLR high ionization lines (such as [O III]), including extended wings (usually blueshifted from the systemic redshift), line asymmetries, and broader line widths than those of low ionization lines (e.g., Heckman et al. 1981; Penston et al. 1984; Rodríguez-Ardila et al. 2006). In the cases of NGC 1068 (e.g., Axon et al. 1998) and Mrk 78 (e.g., Heckman et al. 1981; Pedlar et al. 1989; Whittle & Wilson 2004) known to have biconical

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\(^7\) In principle, an NLR with inflowing gas and dust can also produce the observed features, but this scenario seems less favored considering the difficulty of removing high angular momentum given the large $v_{\text{off}}$ (e.g., Heckman et al. 1981).
outflows, the velocity splitting relative to the systemic redshift is larger on the blueshifted component, which is also brighter and has a larger width than the redshifted component. The statistical significance of these trends is unclear, however (e.g., Whittle et al. 1988). Unlike these, our double-peaked sample has comparable line widths in the blueshifted and redshifted components as shown in Figure 6(d); half of our double-peaked objects have a more prominent redshifted component than the blueshifted component. In addition, our sample has consistent \( v_{\text{off}} \) in \( H\beta \) and in \([\text{O} \, \text{iii}]\) whenever \( H\beta \) is measurable, with no significant ionization stratification as expected in NLR outflows. These possible discrepancies may arise because our sample has appreciably larger \([\text{O} \, \text{iii}]\) luminosity than these previous low-redshift comparison samples, and these properties may be a function of luminosity or redshift or both; alternatively, they may suggest that not all objects in our double-peaked sample exhibit NLR outflows.

Further possible clues come from host-galaxy and line properties. The FIRST-detected fraction for the double-peaked objects is comparable to that of the control sample. The host-galaxy inclination distribution shows no significant difference either, whereas our selection of a large LOS inclination distribution shows no significant difference either, is comparable to that of the control sample. The host-galaxy exhibit NLR outflows. Wilson (1984; Gallimore et al. 2006). In addition, while a correlation between \( v_{\text{off}} \) and line FWHM is observed in NLR outflows (e.g., Komossa et al. 2008), the ratio of velocity shift to line width is of order unity, unlike the ratio of \( \sim 1.5 \) seen in our double-peaked sample. Finally, as shown in Figure 4(b), there is no obvious correlation in our sample between the Balmer decrement and the line-width ratio between the two components of the double-peaked feature (as a proxy for asymmetry). Such a correlation might exist if the blueshifted and redshifted NLR gas components are intrinsically symmetric and the apparent asymmetry results from extinction. Heckman et al. (1981) observed a correlation between the asymmetry of a single line profile (which, however we caution, is different from our asymmetry indicator—the line width ratio of the double-peaked components) and Balmer decrement in a sample of 36 nearby Seyferts thought to contain outflows, although later studies on nearby Seyferts (e.g., Whittle 1985b) found no strong correlations.

### 4.2. Merging SMBH Pairs

Another explanation for the double-peaked features is merging SMBH pairs. In this scenario, both BHs, along with their own NLR gas (with scales of order hundreds of pc), are co-rotating in the galactic potential on \( \gtrsim \text{kpc} \) scales, well before dynamical friction causes their orbit to decay and form a gravitationally bounded compact binary (e.g., Milosavljević & Merritt 2001). The \( v_{\text{off}} - \sigma \) and \( v_{\text{off}} - \text{FWHM} \) correlations in this scenario would naturally arise from dynamics. The comparable numbers of objects with more prominent redshifted and blueshifted components and the null correlation between the Balmer decrement and the double-peak asymmetry may both be accommodated if the two emission components are associated with two SMBHs. The similar distribution of host-galaxy inclination angles to the control sample could be explained, given that there is no preference for the rotation axis of galaxies in the merging SMBH-pair scenario.

On the other hand, the correlation between the diagnostic line ratio \([\text{O} \, \text{iii}]/H\beta\) of the two components shown in Figure 4(a) may be difficult to explain if the NLR gas of each component is primarily ionized by its own BH. In addition, the higher galaxy concentration for objects with double peaks (Figure 5) seems inconsistent with these objects being in the early stage of mergers, although we may be biased to more compact objects by the necessity to get both merging objects within the 3-arcsec fiber aperture. The older mean stellar ages and the smaller post-starburst fraction in the past 0.1–1 Gyr also seem counterintuitive, if there is excess star formation in mergers. However, these differences might also result from the mass–age correlation (e.g., Kauffmann et al. 2003) given that the median \( \sigma \) of the double-peaked sample is larger than that of the control sample (Figure 5), or if the associated star formation is on a different timescale from what is probed by the \( D_n(4000) \) and \( H\alpha \) indices adopted here, or it is suppressed by AGN activity.

In view of the above arguments, we conclude that our double-peaked sample may contain a population of NLR outflows or rotating disks, as well as objects that are merging SMBHs; the statistical properties of the sample do not show any strong preference for or against either scenario. In Figure 2, we show several intriguing cases. The first example (SDSSJ114642.5+511029.9) is a merging system of which the off-centered galaxy is partially covered by the 3-arcsec diameter fiber. We have checked that the two galaxies are both detected in the K\textsubscript{s} band by Two Micron All Sky Survey (2MASS; Skrutskie et al. 2006), and have found evidence that both are AGNs using spatially resolved long-slit spectroscopy, the results of which will be presented elsewhere. Only 13 of the 167 objects in our double-peaked sample show possible evidence for two cores in the SDSS images within the 3-arcsec diameter of the spectroscopic fibers. The second object (SDSSJ122709.8+124854.5) does not have a resolved double core in its SDSS image, and its emission lines have well-separated peaks, symmetrically shifted from the systemic velocity, and the redshifted component is more prominent. High-resolution Hubble Space Telescope (HST) imaging may help reveal potential double cores unresolved in SDSS images (e.g., Comerford et al. 2009a). For example, one of our double-peaked objects (SDSSJ130128.8–005804.3, at \( z = 0.2455 \)) shows no double cores in its SDSS image, but Zakamska et al. (2006) used HST imaging to show that it consists of two galaxies with a projected separation of 1.3 arcsec (corresponding to 5.0 kpc) which well fits into the SDSS 3-arcsec diameter fiber. We will need spatially resolved spectroscopy to determine whether both of the galaxies are AGNs. The last object in Figure 2 has a strong component coincident with the systemic redshift and a weaker blueshifted component and an even weaker redshifted component (not fitted), which could arise from a classic NLR region plus bipolar outflows. Spatially resolved optical imaging, spectroscopy, radio and/or X-ray follow-up are still needed to help draw firm conclusions on the nature of these double-peaked narrow-line objects.

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