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TWO NEW GRAVITATIONALLY LENSED DOUBLE QUASARS FROM THE SLOAN DIGITAL SKY SURVEY

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ABSTRACT

We report the discoveries of the two-image gravitationally lensed quasars SDSS J074653.03+440351.3 and SDSS J140624.82+612640.9, selected from the Sloan Digital Sky Survey (SDSS). SDSS J0746+4403, which will be included in our lens sample for statistics and cosmology, has a source redshift of $z_s = 2.00$, an estimated lens redshift of $z_l \sim 0.3$, and an image separation of 1.08\arcsec. SDSS J1406+6126 has a source redshift of $z_s = 2.13$, a spectroscopically measured lens redshift of $z_l = 0.27$, and an image separation of 1.98\arcsec. We find that the two quasar images of SDSS J1406+6126 have different intervening Mg II absorption strengths, which are suggestive of large variations of absorbers on kiloparsec scales. The positions and fluxes of both lensed quasar systems are easily reproduced by simple mass models with reasonable parameter values. These objects bring to 18 the number of lensed quasars that have been discovered from the SDSS data.

Key words: gravitational lensing — quasars: individual (SDSS J074653.03+440351.3, SDSS J140624.82+612640.9)

1. INTRODUCTION

Gravitationally lensed quasars are unique astronomical and cosmological tools (see the review by Kochanek 2006). They are useful for studying the mass distribution, substructure, and interstellar medium of their lens galaxies and the structure of the quasar host galaxy and accretion disk, and for estimating cosmological models (e.g., Kochanek 1991; Mao & Schneider 1998; Chang &Refsdal 1984; Turner 1990; Fukugita et al. 1990;Refsdal 1964). Lensed quasars due to foreground galaxy clusters probe the distribution of dark matter in the lens objects (Oguri et al. 2004a; Williams & Saha 2004), and their statistics can be a useful test of dark matter models (Narayan & White 1988; Oguri &Keeton 2004). A continuing problem, however, is the limited number of strongly lensed quasars (approximately 100; Kochanek 2006) and the still more limited number found in systematic surveys. In particular, the current largest completed survey, the Cosmic Lens All Sky Survey (CLASS; Myers et al. 2003; Browne et al. 2003), has led to a well-defined statistical sample of only 13 lensed radio sources. While the CLASS can be used to obtain constraints on dark energy (Chae et al. 2002; Mitchell et al. 2005), larger well-defined lens samples are needed to be competitive with other approaches to constraining the cosmological model.

The Sloan Digital Sky Survey (SDSS; York et al. 2000) is currently a better candidate for building a larger, well-defined lensed quasar sample than the CLASS. The SDSS is expected to eventually provide a catalog of roughly 100,000 spectroscopically identified quasars (Schneider et al. 2005; D. P. Schneider et al. 2007, in preparation), and we have been searching for gravitationally lensed quasars in the SDSS Quasar Lens Search (SQLS; Oguri et al. 2006; N. Inada et al. 2006, in preparation). Since the probability of a quasar being multiply imaged is of order $10^{-3}$ (Turner et al. 1984), we have a reasonable expectation of obtaining a well-defined sample of roughly 100 lensed quasars. Including the two new lenses reported here, we have now discovered 18 new lensed quasars (Inada et al. 2003a, 2003b, 2003c, 2005, 2006; Johnston et al. 2003; Morgan et al. 2003; Pindor et al. 2004, 2006; Oguri et al. 2004b, 2005; S. Burles et al. 2007, in preparation; Morokuma et al. 2006; I. Kayo et al. 2007, in preparation) and have recovered eight previously known lensed quasars (Walsh et al. 1979; Weymann et al. 1980; Surdej et al. 1987; Bade et al. 1997; Oscoz et al. 1997; Schechter et al. 1998; Morgan et al. 2001; Magain et al. 1988), making the SQLS the largest survey for gravitational lensed quasars to date.

In this paper we present two new doubly imaged lensed quasars found in the course of the SQLS, SDSS J074653.03+440351.3 (SDSS J0746+4403) and SDSS J140624.82+612640.9 (SDSS J1406+6126). They were confirmed with observations at the W. M. Keck Observatory’s Keck II telescope, the University of Hawaii 2.2 m (UH88) telescope, and the MDM Observatory’s 2.4 m Hiltner (MDM 2.4 m) telescope. The structure of this paper is as follows: We describe our lens candidate selection from the SDSS data in § 2. The results of the imaging and spectroscopic follow-up observations for SDSS J0746+4403 and SDSS J1406+6126 are presented in §§ 3 and 4, respectively. Section 5 discusses the models of the lensed quasars, and we summarize...
our results in § 6. We assume a cosmological model with matter density \( \Omega_M = 0.27 \), cosmological constant \( \Omega_\Lambda = 0.73 \), and Hubble constant \( h = H_0/100 \text{ km s}^{-1} \text{ Mpc}^{-1} = 0.7 \) (Spergel et al. 2003).

2. SELECTION ALGORITHM

The SDSS consists of a photometric survey (Gunn et al. 1998; Lupton et al. 1999; Tucker et al. 2006) in five broadband optical filters (Fukugita et al. 1996) and a spectroscopic survey with a multifiber spectrograph covering 3800–9200 Å at a resolution of \( R \sim 1800 \), both using a dedicated wide-field (3° field of view) 2.5 m telescope (Gunn et al. 2006) at the Apache Point Observatory in New Mexico, USA. The final survey area is about 10,000 deg² of the sky approximately centered on the north Galactic cap. Once the imaging data are processed by the photometric pipeline (Lupton et al. 2001; Lupton 2005), quasar and galaxy candidates are selected for spectroscopy (Eisenstein et al. 2001; Richards et al. 2002; Strauss et al. 2002), and the spectroscopic observations are conducted according to the tiling algorithm of Blanton et al. (2003). The imaging data have an astrometric accuracy better than about 0.1′′ rms per coordinate (Pier et al. 2003) and photometric zero-point errors less than about 0.03 mag over the entire survey area (Hogg et al. 2001; Smith et al. 2002; Ivezić et al. 2004). The SDSS is continuously releasing the data to the public (Stoughton et al. 2002; Abazajian et al. 2003, 2004, 2005; Adelman-McCarthy 2006).

The two objects, SDSS J0746+4403 and SDSS J1406+6126, were selected as lensed quasar candidates from the sample of the SDSS spectroscopically confirmed quasars by two algorithms. The first method is the algorithm we used previously (e.g., Inada et al. 2003a), which identifies close-separation (\( \sim 1.0′′ \)) lens candidates as quasars with low probabilities of being well fitted as a point source, an exponential disk, or a de Vaucouleurs profile. The second is the new algorithm introduced by Oguri et al. (2006) that examines close pairs of objects (quasars); both candidates also satisfy the new morphological selection criteria. We note that SDSS J1406+6126 with \( i_{cor} = 19.31 \) (\( i \)-band point-spread function [PSF] magnitude corrected for Galactic extinction) is slightly fainter than the magnitude limit we are using to construct our statistical lens sample (see Oguri et al. 2006).

Figure 1 shows the SDSS \( i \)-band images of SDSS J0746+4403 and SDSS J1406+6126. The total magnitudes inside a \( \sim 2.0′′ \) aperture radius (without Galactic extinction corrections) and the quasar redshifts from the SDSS imaging and spectroscopic data are summarized in Table 1. Both objects are marginally resolved in the SDSS imaging data and (spatially) unresolved in the SDSS spectroscopic data; thus, additional observations were needed to confirm that they are indeed gravitationally lensed quasars.

3. FOLLOW-UP OBSERVATIONS OF SDSS J0746+4403

We obtained \( V, R, \) and \( i \)-band images of SDSS J0746+4403 with the 8K mosaic CCD camera (UH8K; 0.235″ pixels) and the Orthogonal Parallel Transfer Imaging Camera (OPTIC; 0.137″ pixels) at the UH88 telescope. We also obtained a deep \( r \)-band image with the Retractable Optical Camera for Monitoring (RETROCAM; 0.259″ pixels; Morgan et al. 2005) at the MDM 2.4 m telescope. The observations were conducted on 2004 December 14 (UH8K, \( V \); 0.7″ seeing, 240 s), 2004 December 16

<table>
<thead>
<tr>
<th>Object</th>
<th>( u^a )</th>
<th>( g^a )</th>
<th>( r^a )</th>
<th>( i^a )</th>
<th>( z^a )</th>
<th>Redshift( ^b )</th>
</tr>
</thead>
<tbody>
<tr>
<td>SDSS J0746+4403</td>
<td>18.83 ± 0.03</td>
<td>18.74 ± 0.01</td>
<td>18.70 ± 0.02</td>
<td>18.41 ± 0.02</td>
<td>18.20 ± 0.06</td>
<td>1.998 ± 0.002</td>
</tr>
<tr>
<td>SDSS J1406+6126</td>
<td>19.70 ± 0.07</td>
<td>19.37 ± 0.06</td>
<td>19.21 ± 0.14</td>
<td>19.11 ± 0.18</td>
<td>18.78 ± 0.22</td>
<td>2.134 ± 0.002</td>
</tr>
</tbody>
</table>

\( ^a \) Total magnitudes inside a \( \sim 2.0′′ \) aperture radius and without Galactic extinction corrections from the SDSS data.

\( ^b \) Quasar redshifts from the SDSS spectra.
Fig. 2.—UH8K mosaic CCD V/R/I-band images, the MDM 2.4 m RETROCAM r-band image, and the UH88 OPTIC I-band image of SDSS J0746+4403. The image scales are 0.235" pixel$^{-1}$ for the UH8K, 0.259" pixel$^{-1}$ for the RETROCAM, and 0.137" pixel$^{-1}$ for the OPTIC. The left panels show the original images. In the middle panels we show the residuals after fitting the images using only two PSFs, and the right panels show the residuals after fitting the images using two PSFs plus one galaxy component. Residual fluxes, which originate from the lens galaxy (component G), can be seen in all the middle panels, and no residuals can be seen in any of the right panels. The colors of components A and B are quite similar (see Table 2), and the colors and magnitude of component G are consistent with those of an early-type galaxy at $z \sim 0.3$. 
GALFIT (Peng et al. 2002) to fit the data with two PSFs and an axy. The right panels of Figure 2 show the residuals after using The most natural interpretation is that they come from a lens gal-
tended residual fluxes (named G), particularly in the redder bands.

planes of Figure 2 show the residuals after fitting the images using only two PSFs constructed from nearby stars. In each case there are significant, ex-
tended residual fluxes (named G), particularly in the redder bands.
The most natural interpretation is that they come from a lens gal-
axy. The right panels of Figure 2 show the residuals after using GALFIT (Peng et al. 2002) to fit the data with two PSFs and an extended galaxy (modeled by a Sérisc profile) between them. With

jectories of component A are R.A. = 116.72113° and decl. = +44.06416° (J2000.0).

TABLE 2
ASTROMETRY AND PHOTOMETRY OF SDSS J0746+4403

<table>
<thead>
<tr>
<th>Component</th>
<th>( \Delta X^a ) (arcsec)</th>
<th>( \Delta Y^a ) (arcsec)</th>
<th>( \rho^b )</th>
<th>( \rho^b )</th>
<th>( \rho^b )</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>0.000 ± 0.003</td>
<td>0.000 ± 0.003</td>
<td>19.87 ± 0.01</td>
<td>19.53 ± 0.01</td>
<td>19.08 ± 0.01</td>
</tr>
<tr>
<td>B</td>
<td>-0.933 ± 0.004</td>
<td>0.541 ± 0.004</td>
<td>19.97 ± 0.05</td>
<td>19.55 ± 0.02</td>
<td>19.11 ± 0.01</td>
</tr>
<tr>
<td>G</td>
<td>-0.597 ± 0.041</td>
<td>0.201 ± 0.041</td>
<td>21.57 ± 1.00</td>
<td>20.65 ± 0.05</td>
<td>19.62 ± 0.19</td>
</tr>
</tbody>
</table>

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<tr>
<th>Component</th>
<th>( \Delta X^a ) (arcsec)</th>
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</tr>
</tbody>
</table>

* Measured in the OPTIC i-band image using GALFIT. The positive directions of \( X \) and \( Y \) are defined by east and north, respectively. The celestial coordinates of component A are R.A. = 116.72113° and decl. = +44.06416° (J2000.0).

** Measured in the UH8K VRI-band images using GALFIT. The errors do not include the photometric uncertainty of the standard star.

in Table 3, the quasar redshifts and emission-line widths are consistent with the hypothesis that the spectra are identical.

4. FOLLOW-UP OBSERVATIONS OF SDSS J1406+6126

Since it was obvious that a galaxy is associated with the quasar SDSS J1406+6126 even in the SDSS images, we acquired a 90 s short-exposure UH8K V-band image on 2005 May 7 (0.8” seeing) in order to see if there were multiple stellar (quasar) images. As shown in Figure 4 (top left), it turned out that the object consists of two stellar components (components A and B, with A being the brighter component) and an extended object (component G) between them. We obtained a deeper and higher spatial resolution i-band image with the OPTIC camera on 2006 May 3 (1.0” seeing, 300 s), which is also shown in the left column of Figure 4. We again find that the residuals using a fit consisting of only two PSFs are significant (Fig. 4, middle panels), while a model consisting of two PSFs plus an extended component fits the images well (Fig. 4, right panels). The observed color of component G (\( V - I \sim 1.7 \)) is also typical of an early-type galaxy at the spectroscopic redshift of \( z = 0.27 \) that we discuss later in this section (Fukugita et al. 1995). The relative astrometry from the OPTIC i-band image and the absolute photometry from the UH8K V-band

(\( UHK, R \) and \( I, 0.8” seeing, 360 and 270 s), 2006 February 23 (RETROCAM, \( r, 1.0” \) seeing, 2700 s), and 2006 May 3 (OPTIC, \( I, 1.0” \) seeing, 300 s). In all these images, which are shown in the left panels of Figure 2, we observe two stellar components (denoted as A and B, A being the eastern component) with a separation of 1.079” \( \pm 0.010” \). The middle panels of Figure 2 show the residuals after fitting the images using only two PSFs constructed from nearby stars. In each case there are significant, ex-
tended residual fluxes (named G), particularly in the redder bands.
The most natural interpretation is that they come from a lens gal-
axy. The right panels of Figure 2 show the residuals after using GALFIT (Peng et al. 2002) to fit the data with two PSFs and an extended galaxy (modeled by a Sérisc profile) between them. With

We obtained 1200 s spectra of components A and B with the Echelle Spectrograph and Imager (ESI; Sutin 1997; Sheinis et al. 2002) and the MIT Lincoln Laboratory 2048 \( \times \) 4096 CCD

detector at the Keck II telescope on 2006 March 5 (0.8” seeing). The wavelength coverage was 3900–11000 \( \AA \) with a spectral dispersion of \( \sim 0.25” \) \( \text{Å} \) pixel\(^{-1}\). The spatial sampling scale of the CCD detector is 0.154” pixe\( \text{l}^{-1}\), and we used a 1.0” wide slit aligned to observe components A and B simultaneously. Since the spectra of the two components were well separated in the spectral CCD image, we were able to extract the spectra of the two quasars using standard IRAF\(^{16}\) tasks. We calibrated the spectra using the spectroscopic standard G191-B2B (Oke 1990), and the telluric lines were corrected using a high-resolution model of the absorption bands derived from ESI observations of standard stars. The binned spectra of components A and B, whose bad pixels and bad columns were corrected by linear interpolation, are shown in the top panel of Figure 3, and the ratio of the spectra is shown in the bottom panel. The spectral flux ratios of both the continuum and the \( \text{Si} \text{iv}, \text{C} \text{iv}, \text{C} \text{iii}, \text{and Mg} \text{ii} \) emission lines are remarkably similar, with an overall flux ratio of \( \sim 1 \). As reported

\(^{16}\) IRAF is the Image Reduction and Analysis Facility, a general-purpose software system for the reduction and analysis of astronomical data. IRAF is written and supported by the IRAF programming group at the National Optical Astronomy Observatory (NOAO) in Tucson, Arizona. NOAO is operated by the Association of Universities for Research in Astronomy, Inc., under cooperative agreement with the National Science Foundation.

**FIG. 3.**—Binned and bad-pixel (bad-column) – corrected spectra of components A (black solid line, shifted upward by a constant of \( 2.0 \times 10^{-17} \)) and B (gray solid line) of SDSS J0746+4403, taken with the ESI at the Keck II telescope. The original spectra have a reciprocal dispersion of \( \sim 11.4 \) km s\(^{-1}\) pixel\(^{-1}\). The vertical dotted lines indicate the positions of the quasar \( \text{Si} \text{iv}, \text{C} \text{iv}, \text{C} \text{iii}, \text{and Mg} \text{ii} \) emission lines redshifted to \( z = 2.00 \). In addition to the emission lines, there is a common C iv absorption system at \( \sim 4540 \) Å (\( \chi_{\text{abs}} = 1.93 \)) in the spectra of components A and B, and there is a weak (REW\( \text{Mg} \text{ii} \leq 0.3 \)) Mg ii absorption system at \( \sim 7430 \) Å (\( \chi_{\text{abs}} = 1.65 \)) in the spectrum of component A. The spectral flux ratio of components A and B is nearly constant, as shown in the bottom panel.
TABLE 3  
**Emission Lines of SDSS J0746+4403 Spectra**

<table>
<thead>
<tr>
<th>Line</th>
<th>Component A</th>
<th>Component B</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$\lambda_{\text{obs}}$ (Å)</td>
<td>FWHM (Å)</td>
</tr>
<tr>
<td>Si iv (1396.76)</td>
<td>4196.90</td>
<td>107.5</td>
</tr>
<tr>
<td>C iv (1549.06)</td>
<td>4654.18</td>
<td>95.8</td>
</tr>
<tr>
<td>C iii (1908.73)</td>
<td>5725.77</td>
<td>119.2</td>
</tr>
<tr>
<td>Mg ii (2798.75)</td>
<td>8402.93</td>
<td>155.7</td>
</tr>
</tbody>
</table>

**Fig. 4.**—UH8K $V$-band image and OPTIC $I$-band image of SDSS J1406+6126. The format of the figure is the same as in Fig. 2. An extended object can be seen between the two stellar components even in the original images, and its presence is obvious in the middle panels showing the residuals from a fit consisting only of two PSFs, while the model consisting of two PSFs plus an extended galaxy fits the data very well (*right panels*). The colors of components A and B are quite similar (Table 4), and the color of component G is consistent with that of an early-type galaxy at $z_l = 0.2$, which is in good agreement with its spectroscopic redshift of $z_l = 0.27$.

TABLE 4  
**Astrometry and Photometry of SDSS J1406+6126**

<table>
<thead>
<tr>
<th>Object</th>
<th>$\Delta X^a$ (arcsec)</th>
<th>$\Delta Y^a$ (arcsec)</th>
<th>$I^b$</th>
<th>$f^b$</th>
</tr>
</thead>
<tbody>
<tr>
<td>A......</td>
<td>0.000 ± 0.004</td>
<td>0.000 ± 0.004</td>
<td>19.99 ± 0.01</td>
<td>19.38 ± 0.01</td>
</tr>
<tr>
<td>B......</td>
<td>−1.639 ± 0.007</td>
<td>−1.103 ± 0.007</td>
<td>20.60 ± 0.03</td>
<td>19.97 ± 0.04</td>
</tr>
<tr>
<td>G......</td>
<td>−1.143 ± 0.006</td>
<td>−0.727 ± 0.006</td>
<td>19.86 ± 0.07</td>
<td>18.12 ± 0.02</td>
</tr>
</tbody>
</table>

*a* Measured in the OPTIC $I$-band image using GALFIT. The positive directions of $X$ and $Y$ are defined by east and north, respectively. The celestial coordinates of component A are R.A. = 211.60344° and decl. = +61.44474° (J2000.0).

*b* Measured in the UH8K $V$-band image and OPTIC $I$-band image using GALFIT. The errors do not include the photometric uncertainty of the standard star.
The angular separation of components A and B is with similar widths (see Table 5). However, both spectra clearly have quasar emission lines at the same redshift and have a reciprocal dispersion of $\frac{8}{C_{24}}$. Indicate the positions of the quasar Si iv components A ($\lambda_{\text{abs}} = 1396.76$) and B at $z = 0.27$. The vertical dotted lines show the positions of the lens galaxy absorption lines (Ca ii H and K, G band, Mg, and Na) redshifted to $z = 0.27$.

There are two interesting Mg ii absorption systems in the spectra of SDSS J1406+6126. There is an absorption system at $z_{\text{abs}} = 0.691 (\sim 4730 \, \text{Å})$ with a Mg ii $\lambda 2796$ rest-frame equivalent width (REW$_{\text{Mg} \, ii}$) of $1.3 \, \text{Å}$ in the spectrum of component A that is absent (REW$_{\text{Mg} \, ii} < 0.3$) from the spectrum of component B. A second system at $z_{\text{abs}} = 1.562 (\sim 7150 \, \text{Å})$ has a REW$_{\text{Mg} \, ii}$ of $1.3 \, \text{Å}$ in component A but only $0.3 \, \text{Å}$ in component B. These large equivalent-width differences are occurring on scales of only $5.3 (h/0.7)^{-1} \, \text{kpc}$ for $z_{\text{abs}} = 0.691$ and $1.1 (h/0.7)^{-1} \, \text{kpc}$ for $z_{\text{abs}} = 1.562$, respectively. Such large fractional changes have been seen only for weak absorption systems (REW$_{\text{Mg} \, ii} \lesssim 0.3 \, \text{Å}$), as shown in Figure 10 of Ellison et al. (2004). Large REW$_{\text{Mg} \, ii}$ variations on kiloparsec scales in strong intervening absorption systems, such as those we have found in the SDSS J1406+6126 spectra, could indicate a range of size scales for such absorption systems or could just be rare outliers.

5. Lens Models

The follow-up data strongly support the hypothesis that both objects are two-image gravitational lenses. To do our final test that the hypothesis is reasonable, we modeled both systems using a standard mass model consisting of a singular isothermal sphere with an external shear. The models have just as many parameters as the three component positions and the two quasar fluxes), so the number of degrees of

Table 5

<table>
<thead>
<tr>
<th>Line</th>
<th>Component A</th>
<th>Component B</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\lambda_{\text{abs}}$ (Å)</td>
<td>FWHM (Å)</td>
<td>Redshift</td>
</tr>
<tr>
<td>Si iv (1396.76)</td>
<td>4376.51</td>
<td>90.6</td>
</tr>
<tr>
<td>C iv (1549.06)</td>
<td>4842.11</td>
<td>73.9</td>
</tr>
<tr>
<td>C II (1308.73)</td>
<td>5975.09</td>
<td>73.6</td>
</tr>
<tr>
<td>Mg ii (2798.75)</td>
<td>8766.79</td>
<td>83.4</td>
</tr>
</tbody>
</table>

We used the formulae quoted in Smette et al. (1992) to calculate the proper separation between the lensed quasar images.
freedom is 0. Thus, we expect the mass model to be able to fit the data perfectly, and the only check on the models is the degree to which the parameters are physically reasonable. We adopt
the relative positions and $I$-band flux ratios from Table 2 and Table 4 as constraints.

We use the lensmodel software (Keeton 2001) to fit the models, and the parameters of the best-fitting models ($\chi^2 = 1$) errors are summarized in Table 6. The external shears of $\gamma \sim 0.03$ required to fit the data are typical for lensed quasars (e.g., Oguri et al. 2005; Inada et al. 2006). The predicted time delays and total magnifications are $\Delta t \approx 3$ days and $\mu_{\text{tot}} \approx 13$ for SDSS J0746+4403, and $\Delta t \approx 20$ days and $\mu_{\text{tot}} \approx 5$ for SDSS J1406+6126.

### 6. SUMMARY

We have discovered two new lensed quasars in the SDSS: SDSS J0746+4403 and SDSS J1406+6126. SDSS J0746+4403 is a two-image lens ($\Delta \theta = 1.98''$) formed from a $z = 2.00$ quasar by a foreground galaxy at $z_1 \sim 0.3$. The redshift of the lens galaxy was estimated from its colors and $I$-band magnitude. SDSS J1406+6126 is a two-image lens ($\Delta \theta = 1.98''$) formed from a $z = 2.13$ quasar by a spectroscopically confirmed lens galaxy at $z_1 = 0.27$. Both lenses have properties that are easily reproduced by standard lens models with reasonable parameters. SDSS J0746+4403 is particularly important because it will be included in the well-defined statistical sample of the QSOs that we plan to use to constrain the cosmological model. SDSS J1406+6126 is slightly fainter than our magnitude limit for the statistical sample, but the relatively large image separation and the bright lens galaxy should make it a useful lens for studying the structure of early-type galaxies. A particularly interesting feature of SDSS J1406+6126 is that it has two strong Mg ii absorption-line systems that show dramatic changes on the few-kiloparsec scales of the path separations, which could provide a useful insight into the size distribution of absorption systems. Spectroscopy to measure the redshifts and velocity dispersions of the lens galaxies, high-resolution imaging to determine the structures of the lens galaxies, and measurements of the time delays are the next steps toward using these lenses to study the structure and evolution of galaxies.

Use of the University of Hawaii 2.2 m telescope for the observations is supported by National Astronomical Observatory of Japan. Some of the data presented herein were obtained at the W. M. Keck Observatory, which is operated as a scientific partnership among the California Institute of Technology, the University of California, and the National Aeronautics and Space Administration. The Observatory was made possible by the generous financial support of the W. M. Keck Foundation. This work is also based in part on observations obtained with the MDM 2.4 m Hiltner telescope, which is owned and operated by a consortium consisting of Columbia University, Dartmouth College, the University of Michigan, the Ohio State University, and Ohio University. We would like to thank D. Depoy, J. Eastman, S. Frank, and J. Marshall of Ohio State University, and J. Halpern of Columbia University for operating the MDM queue observing and monitoring program.

N. I. is supported by the Japan Society for the Promotion of Science (JSPS) through a JSPS Research Fellowship for Young Scientists. This work was supported in part by Department of Energy contract DE-AC02-76SF00515. A portion of this work was also performed under the auspices of the US Department of Energy, National Nuclear Security Administration, by the University of California, Lawrence Livermore National Laboratory, under contract W-7405-Eng-48. I. K. acknowledges support from a Ministry of Education, Culture, Sports, Science, and Technology Grant-in-Aid for Encouragement of Young Scientists (17740139).

Funding for the SDSS and SDSS-II has been provided by the Alfred P. Sloan Foundation, the Participating Institutions, the National Science Foundation, the US Department of Energy, the National Aeronautics and Space Administration, the Japanese Mombukagakusho, the Max Planck Society, and the Higher Education Funding Council for England. The SDSS Web site is at http://www.sdss.org.

The SDSS is managed by the Astrophysical Research Consortium for the Participating Institutions. The Participating Institutions are the American Museum of Natural History, the Astrophysical Institute Potsdam, the University of Basel, Cambridge University, Case Western Reserve University, the University of Chicago, Drexel University, Fermilab, the Institute for Advanced Study, the Japan Participation Group, the Johns Hopkins University, the Joint Institute for Nuclear Astrophysics, the Kavli Institute for Particle Astrophysics and Cosmology, the Korean Scientist Group, the Chinese Academy of Sciences, Los Alamos National Laboratory, the Max Planck Institute for Astronomy, the Max Planck Institute for Astrophysics, New Mexico State University, the Ohio State University, the University of Pittsburgh, the University of Portsmouth, Princeton University, the United States Naval Observatory, and the University of Washington.

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