ESO-VLT optical spectroscopy of BL Lac objects: I. new redshifts.

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ABSTRACT

We report redshift measurements for 12 BL Lacertae objects from a program aimed at obtaining high signal to noise (up to $\sim 500$) optical spectroscopy of a mixed sample of objects. The new observations, gathered with the 8 m ESO Very Large Telescope, allowed us to detect weak spectral features down to a line equivalent width as small as $\sim 1$ Å. The new redshifts fall in the 0.2–1.3 interval. For nine objects we observe emission lines from the active nucleus. In the remaining three cases absorption lines from the host galaxy are found. For two objects we also detect absorption lines from intervening systems.

\textit{Subject headings:} BL Lacertae objects: general

1. Introduction

BL Lac objects are active galactic nuclei (AGN) exhibiting strong nonthermal emission, superluminal motion, rapid and large flux and polarization variability. In contrast with other classes of AGN, their spectra are characterized by the absence or extreme weakness of emission lines.

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In the standard model of BL Lacs, the weak emission lines (if present) are generated by fluorescence, as in other types of AGN. The line equivalent width (EW) is reduced by the strong beamed continuum, caused by the alignment with our line of sight of the relativistic jet produced by the nucleus. On the other hand absorption lines can be produced either from spectral features of the stellar population of the host galaxy or from intervening halos as in the case of quasars (mainly for high redshift sources). Detectability of the absorption features depends inversely on the brightness state of the central source. Because of the weakness of the emission lines (usually \( \text{EW} \lesssim 5 \, \text{Å} \)) and the relatively bright central continuum source with respect to the emission from the host galaxy, in many cases the redshift of these objects is unknown and/or very uncertain. The obvious implication of this is that the distance of the sources remains undetermined, hampering a proper evaluation the physical parameters of the objects.

In the past decade a number of projects were carried out to derive the redshift of BL Lac objects either for selected targets or to obtain as much redshift information as possible for complete samples of BL Lacs. Apart from Heidt et al. (2004) all previous works (e.g. Stickel, Fried, & Kuehr 1993; Véron-Cetty & Véron 1993; Bade, Fink, & Engels 1994; Véron 1994; Marcha et al. 1996; Drinkwater et al. 1997; Landt et al. 2001; Rector & Stocke 2001; Londish et al. 2002; Carangelo et al. 2003; Hook et al. 2003) were based on optical spectra collected with \( \leq 4 \) m class telescopes and are therefore limited by either relatively low S/N (\( \lesssim 50 \)) or to bright objects (\( m_V < 15 \)). As a result of this in spite of the use of relatively large aperture telescopes in a number of cases the redshift remained unknown. Since the detection of spectral features critically depends on the S/N of the spectra it is clear that a further step towards the knowledge of the redshift of BL Lacs requires the use of 8m class telescopes.

With these aims in mind we have carried out a project to secure optical spectra of BL Lacs of still unknown or uncertain redshift with the highest possible S/N using VLT in service mode. Such a program can be executed even during non photometric sky and poor seeing conditions and does not interfere with higher priority programs performed at large aperture telescopes. We selected sources from various lists of BL Lacs (e.g. Padovani & Giommi 1995; Véron-Cetty & Véron 2003) with \( 15 < m_V < 22 \) and \( \delta < 20^\circ \) thus ensuring to obtain high S/N spectra with reasonable exposure times at VLT. Under these assumptions we constructed a sample of \( \sim 60 \) targets. 31 have been observed in the first two campaigns while the others are scheduled. Of these observed sources 12 have featureless spectra, 2 turn out to be galactic stars, 2 are early type galaxies, 3 are high redshift quasars and 12 are BL Lacs for which the redshift has been measured by us.

In this paper we report the results concerning these 12 objects. A full account of the observations for the featureless BL Lacs and the other sources will be presented in a later publication. The outline of this work is as follows: in section 2 we describe the observations and the data analysis; the results for individual objects are presented in section 3 and finally we give in section 4 a brief discussion of our findings.

To compute absolute quantities we adopted a cosmology with \( H_0=70 \, \text{km s}^{-1} \, \text{Mpc}^{-1}, \Omega_M=0.3, \)
2. Observations and data analysis

Optical spectra were collected in service mode in Paranal (Chile) with VLT UT1 (Antu) equipped with FORS1 (Appenzeller et al. 1998) in the period April 2003 to March 2004. We used the 300V+I grism combined with a 2” slit, yielding a dispersion 110 Å/mm (corresponding to 2.64 Å/pixel) and spectral resolution=15–20 Å covering the 3800–8000 Å range. The seeing during observations was in the range 0.5–2.5”, with an average of ∼1”. A list of the observed objects, along with relevant informations, is given in table 1.

Data reduction was performed using IRAF\(^1\) (Tody 1986, 1993) following standard procedures for spectral analysis. For each target we obtained three individual spectra in order to produce adequate correction of cosmic rays and, eventually, to provide independent check of weak features. The individual frames were then combined into a single average spectrum and processed. Wavelength calibration was performed using the spectra of a Helium Neon Argon lamp obtained during the same observing night. This allows one to obtain wavelength calibrated spectra with an accuracy of ∼ 3 Å(rms). From these calibrated images we extracted one-dimensional spectra adopting an optimal extraction algorithm (Valdes 1992) to improve the S/N.

Although this program did not require good photometric conditions most of the observations were obtained during clear nights. This enables us to perform a spectrophotometric calibration of the acquired data using observations of standard stars (Oke 1990) observed in the same nights. From the photometric database at Paranal we estimate that a photometric accuracy of 10% was reached during our observing nights. The spectra were also corrected for Galactic extinction, using the extinction law by Cardelli, Clayton, & Mathis (1989) and assuming values of E(B-V) from Schlegel, Finkbeiner, & Davis (1998). We calculated the spectral index of the dereddened spectra, fitting to the continuum a simple power-law \( F_\lambda \propto \lambda^{-\alpha} \).

In order to detect faint spectral features we evaluate for each spectrum the minimum measurable EW. This quantity was derived computing the EW for each interval of wavelengths of fixed size (20 Å) along the whole spectrum but excluding the telluric absorptions. In each spectral bin we evaluate the EW, as the integral of the \((F_\lambda-F_{\text{cont}})/F_{\text{cont}}\) where \(F_\lambda\) is the total flux inside the bin, and \(F_{\text{cont}}\) is the continuum flux inside the bin. \(F_{\text{cont}}\) is obtained from a linear interpolation of the fluxes in the adjacent bins. Where no spectral features are present the EW measurements yields a value around zero and their distribution gives a representation of the noise in the actual spectrum. We assume that a spectral line is significant when its EW is larger than 3 times the rms of the distribution. This is also taken as the minimum detectable EW (\(\text{EW}_{\text{min}}\)). An example

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\(^1\)IRAF is distributed by the National Optical Astronomy Observatories, which are operated by the Association of Universities for Research in Astronomy, Inc., under cooperative agreement with the National Science Foundation.
of this procedure is shown in Figure 1. All the features above the threshold were considered as line candidates and were carefully visually inspected. For the spectra presented here the $EW_{\text{min}}$ ranges from $\sim 1$ Å to 0.1 Å and it is clearly well correlated with the S/N of each spectrum, which was taken in a 100 Å wide bin, centered at 6100 Å (see Figure 2). Line centers and FWHM were determined using a gaussian fit to the line profile.

3. Results for individual sources

The calibrated spectra, corrected for the galactic extinction, are given in Figure 3. Line identifications and parameters, redshift estimates, observed V magnitudes (obtained from the monochromatic flux at 5500 Å) and continuum slopes are given in table 2. The observed magnitudes of our targets are consistent with the values reported in the Véron-Cetty & Véron (2003) catalogue within $\sim$0.5 magnitudes. This is well within the range of the optical variability of BL Lac objects. The typical uncertainty of the measured redshift is $\Delta(z) \sim$0.001. We report here some comments on individual sources:

1RXS J022716.6+020154 Previous spectra obtained by Nass et al. (1996) are featureless. Images taken by Nilsson et al. (2003) detected the host galaxy with $m_R=19.6$. Our high S/N spectrum clearly exhibits absorption features of the host galaxy (Ca II and G band absorptions) at $z=0.457$ (corresponding to a host galaxy magnitude $M_R=-23.1$). This agrees with the photometric estimate of the redshift ($z \sim 0.45$) by Nilsson et al. (2003) based on the host galaxy position on the fundamental plane. The G band 4305 Å is contaminated by telluric absorption. Absorption features of the interstellar medium (ISM) of our galaxy are also detected: diffuse interstellar bands (DIB) at 4428 Å and 4726 Å, and NaI at 5892 Å.

PKS 0306+102 On the basis of a single emission line identified with MgII 2798 Å, Véron (1994) proposed a tentative redshift of 0.863. Our spectrum clearly shows this line together with CII 2326 Å, [NeV] 3426 Å, [OII] 3727 Å and [NeIII] 3869 Å. The spectrum shows also the NaI 5892 Å absorption feature from the ISM of our galaxy. This yields a firm redshift determination of $z=0.862$. We note that, on the basis of the EW of the emission lines, this object seems to be of intermediate nature between a BL Lac and a polarized QSO, as already suggested also by Véron (1994).

1RXS J031615.0−26074 Previous spectra obtained by Bade, Fink, & Engels (1994) are featureless. In our spectrum we observe a faint [OII] 3727 Å emission line, the CaII 3934, 3968 Å and G band 4305 Å absorption features at $z=0.443$. The NaI 5892 Å absorption from the ISM of our galaxy is also detected.
PKS 0338-214  Wright, et al. (1977) reported a tentative redshift estimate of z=0.048, based on the detection of H$_\beta$, Mg H and H$_\alpha$. These features were not confirmed by Falomo, Scarpa, & Bersanelli (1994) and Falomo & Ulrich (2000). Based on the host galaxy detection (m$_R$=18.86), Falomo & Ulrich (2000) proposed a photometric redshift of $\sim$0.45. Our VLT spectrum clearly shows the [OII] 3727 Å and [OIII] 5007Å emission lines at z=0.223. At this redshift the host galaxy has an absolute magnitude M$_R$=-21.7. We observe also the NaI 5892 Å absorption line and the 5772 Å DIB produced by our galaxy ISM.

PKS 0426-380  The only spectral feature detected by Stickel, Fried, & Kuehr (1993) is the intervening system at z=1.030. Consistently with the high redshift Urry et al. (2000) did not detect the host galaxy in their HST image. Heidt et al. (2004) proposed z=1.111 based on the detection of a single emission line identified with the MgII 2798 Å. In our spectrum we detect MgII 2798 Å at z=1.112, and also CIII] and [OII] 3727 Å at z=1.098 and 1.099, respectively. There is a velocity difference of $\sim$1800 km s$^{-1}$ between MgII and the other lines. This is not uncommon for AGN (e.g. McIntosh et al. 1999, and references therein), although the difference is rather large (see also Aoki, Kawaguchi, & Ohta 2004). In addition we also detect the intervening systems at z=1.030 and z=0.559 (reported also by Heidt et al. 2004), and the CaII 3934, 3968 Å absorption lines from the ISM of our galaxy. This source exhibits the largest luminosity for the MgII emission line of the objects examined here.

1RXS J055806.6−383829  The observations of this source performed by Giommi et al. (1989) gave a featureless optical spectrum. Our spectrum clearly shows the host galaxy spectral features (CaII 3934, 3968 Å, G band 4305 Å and MgI 5175 Å absorption lines) at z=0.302. We see also several absorption features from the ISM of our galaxy: DIB at 4726 Å and 5772 Å, and the NaI 5892 Å absorption line. The spectral index found by Giommi et al. (1989) is $\alpha$ =1.8, steeper than our result of 1.2.

PKS 0808+019  The spectrum obtained by Véron-Cetty & Véron (2003) shows no spectral features. A tentative redshift z=0.93 based on a possible detection of MgII 2798 Å was proposed by Jackson et al. (2002) (see also Baldwin, Wampler, & Burbidge 1981; Strittmatter, Carswell, & Gilbert 1974). In our higher S/N spectrum we detect CIII] 1909 Å and MgII 2798 Å emission lines at z=1.148. CaII 3934, 3968 Å, NaI 5892 Å and the DIB at 5772 Å absorption features originated by our galaxy ISM are also observed.

1WGAJ1012.2+063  The optical spectrum obtained by Wolter et al. (1997) failed to detect any feature in this source. Our higher S/N spectrum clearly shows two faint emission lines that we identify with MgII 2798 Å and [OII] 3727 Å at z=0.727. We found also an intervening absorption line at 4246 Å which we identify as MgII 2798 Å at z=0.518. This spectrum presents also several
absorption features from our galaxy ISM: we observe DIB at 4726 and 5772 Å, along with CaII 3934, 3968 Å and NaI 5892 Å atomic lines.

PKS 1250-330 Previous spectroscopic observations of this source by Hook et al. (2003) suggested the presence of a weak emission line at 5202 Å. Our spectroscopy confirms with high confidence this broad emission line which we identify with MgII 2798 at z=0.856. As in the case of PKS 0306+102, the EW of the emission line suggests an intermediate classification between a BL Lac and a QSO.

PKS 1256-229 We detect [OII] 3727 Å and [OIII] 5007 Å narrow emission lines at z=0.481. This contrasts with the claim of z=1.365 proposed by Drinkwater et al. (1997) without any specification of the observed lines. Our visual inspection of the spectrum of Drinkwater et al. (1997), published on a micro-fiche, does not reveal any significant spectral feature. The continuum shape around 3900 Å suggests the presence of the CaII break. However, the expected location of the CaII 3934, 3968 Å doublet is contaminated by the NaI 5892 Å interstellar absorption. DIB at 4428 Å and 4726 Å are also detected.

PKS 1519-273 Our VLT spectra yield z=1.297 and confirm the results obtained by Heidt et al. (2004) who detect an emission line identified as Mg II 2798 Å giving z= 1.294. Several absorption features from the ISM of our galaxy are observed in this spectrum: DIB at 4428 Å, 4726 Å, 4882 Å and 5772 Å, along with CaII 3934, 3968 Å and NaI 5892 Å atomic lines. Although the redshift of this source is based only on a single line, the value z=0.07, proposed by Zensus et al. (2002) (no spectrum published), appears inconsistent with our data.

PKS 2354-021 The spectrum obtained by Hook et al. (2003) for this object is featureless. We clearly detect an emission line which we identify as MgII 2798 Å at a redshift z=0.812. On this spectrum we observe also the CaII 3934, 3968 Å absorption feature from our galaxy ISM.

4. Conclusions

In this work we have described high S/N spectroscopic observations of 12 BL Lac objects from which the redshift, in the range 0.2<z<1.3, has been derived. While the targets discussed in this paper do not represent a statistical sample, some considerations on the results summarized in table 2 can be proposed.

In three cases we have detected faint (EW are ~1 Å) absorption lines from the host galaxy. These refer to nearby objects with 0.3<z<0.5. Only for one of them (1RXS J022716.6+020154) the host galaxy was also detected by imaging. The others are therefore good candidates for follow up imaging studies.
For nine objects the redshift derives from broad and/or narrow emission lines in the range $0.2 < z < 1.2$. For six objects two or more emission lines are observed, providing secure determination of the redshift. Only in three cases a single broad emission line is detected. The redshift for these objects derive from the plausible identification of this line as MgII 2798 Å and because of this should be regarded as tentative.

For seven BL Lac objects we have detected the MgII 2798 Å emission line with a luminosity in the range from $0.5 \times 10^{42}$ erg s$^{-1}$ to $7.0 \times 10^{42}$ erg s$^{-1}$, (mean luminosity $1.9 \times 10^{42}$ erg s$^{-1}$). These luminosities are about one order of magnitude less than the characteristic luminosity of Mg II line in normal quasars (Puchnarewicz et al. 1997). In Figure 4 we compare our new measurements with previous data (Scarpa & Falomo 1997; Stickel, Fried, & Kuehr 1993) for BL Lacs and blazars over the the continuum vs line luminosity plane. Our sources cover the lower luminosity region of this plane and conform to the behavior of the objects in the class. A correlation between the line and the continuum luminosities is apparent over four dex although part of it is induced by the correlation with the redshift (partial correlation coefficient $L_{\text{line}} - L_{\text{cont}} = 0.70$ after removing the effect due to the correlation with redshift). At any given continuum luminosity there is a spread of about 2 dex in line luminosity which translates into a difference of about two orders of magnitude in the observed EW. Although the objects appear uniformly distributed in EW, this difference has contributed to a different classification of the sources (BL Lacs, HPQs, see also Scarpa & Falomo (1997)).

**Acknowledgments:** We acknowledge the EC funding under contract HPRCN-CT-2002-00321 (ENIGMA network), and the Italian MIUR funding, COFIN 2002-027145.
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Fig. 1.— Distribution of EW for the object 1RXJ022716+020154. Left panel: histogram of the distribution of the EW values. Dashed lines show the gaussian fit to the distribution; dotted lines represent EW$_{\text{min}}$. Right panel: EW distribution as a function of the wavelength. Emission lines correspond to negative values of EW, absorption to positive values.
Fig. 2.— $S/N$ level vs. the minimum detectable equivalent width $EW_{\text{min}}$. Points shows the values for the observed spectra. The dashed line shows the $EW_{\text{min}} \propto S/N^{-1}$ correlation.
Fig. 3.— Spectra of the observed objects. Top panels: flux calibrated and dereddened spectra. Bottom panels: normalized spectra. Telluric bands are indicated by ⊕, spectral lines are marked by the line ID, intervening MgII absorption systems are reported as "int. MgII", absorption features
Fig. 3.— continued.
Fig. 3.— continued.
Fig. 4.— MgII 2798 Å line luminosity versus continuum luminosity. Open and filled squares are HPQ and BL Lacs from Scarpa & Falomo (1997), filled circles are BL Lacs from Stickel, Fried, & Kuehr (1993), filled triangles are our data. Dotted lines indicate the loci of EW =0.1, 1, 10 Å.
### Table 1. Journal of observations

| Object          | RA (J2000) | Dec (J2000) | V magnitude | Class | Date     | Exposure time | S/N | Ref.         |
|-----------------|------------|-------------|-------------|-------|----------|---------------|-----|--------------|
| 1RXS J022716.6+020154 | 02 27 16.6 | +02 01 58.0 | 18.8        | H     | 24 Dec 03 | 2325          | 100 | NA96         |
| PKS 0306+102    | 03 09 03.6 | +10 29 12.3 | 18.4        | L     | 19 Nov 03 | 2325          | 20  | CO77, VE94   |
| 1RXS J031615.0−26074 | 03 16 15.0 | −26 07 56.7 | 17.5        | L     | 19 Nov 03 | 2325          | 130 | BA94, BA00   |
| PKS 0338−214    | 03 40 35.5 | −21 19 31.2 | 17.1        | L     | 19 Nov 03 | 2325          | 210 | FA94, FA00   |
| PKS 0426−380    | 04 28 40.4 | −37 56 19.6 | 19.0        | L     | 31 Jul 03 | 1800          | 100 | ST93, HE04   |
| 1RXS J055806.6−383829 | 05 58 06.2 | −38 38 27.0 | 17.1        | H     | 25 Dec 03 | 2325          | 280 | KO92         |
| PKS 0808+019    | 08 11 26.7 | +01 46 52.2 | 17.2        | L     | 25 Dec 03 | 2325          | 140 | VE93         |
| 1WGA J1012.2+063 | 10 12 12.2 | +06 31 01.0 | 16.8        | L     | 30 Dec 03 | 2325          | 200 | WO97         |
| PKS 1250−33     | 12 52 58.4 | −33 19 59.3 | 21.5        | L     | 24 Jan 04 | 2325          | 30  | DR97         |
| PKS 1256−229    | 12 59 08.5 | −23 10 38.7 | 16.7        | L     | 27 Jan 04 | 2325          | 170 | DR97         |
| PKS 1519−273    | 15 22 37.7 | −27 30 10.8 | 17.7        | L     | 30 Apr 03 | 2325          | 170 | PE98, HE04   |
| PKS 2354−021    | 23 57 25.1 | −01 52 15.3 | 21.2        | L     | 17 Sep 03 | 2325          | 30  | HO03         |

Note. — Description of columns: (1) Object name; (2) Right Ascension (J2000); (3) Declination (J2000); (4) V magnitude from Véron-Cetty & Véron (2003) catalogue; (5) Object class (H: High energy peaked BL Lac, L: Low energy peaked BL Lac, as defined by Padovani & Giommi (1995)); (6) date of observations; (7) Exposure time (seconds); (8) Signal to Noise; (9) Reference to previous optical observations CO77: Condon, Hicks, & Jauncey (1977); KO92: Kotilainen et al. (1992); VE93: Véron-Cetty & Véron (1993); ST93: Stickel, Fried, & Kuehr (1993); BA94: Bade, Fink, & Engels (1994); FA94: Falomo, Scarpa, & Bersanelli (1994); VE94: Véron (1994); NA96: Nass et al. (1996); DR97: Drinkwater et al. (1997); WO97: Wolter et al. (1997); PE98: Perlman et al. (1998); BA00: Bauer, Condon, Thuan, & Broderick (2000); FA00: Falomo & Ulrich (2000); HO03: Hook et al. (2003); HE04: Heidt et al. (2004).
| Object name                  | $z_{avg}$ | $\alpha$ | $V$ | Line ID | $\lambda$ | $z$ | Type | FWHM | EW | Line luminosity |
|-----------------------------|-----------|----------|-----|---------|-----------|-----|------|------|----|----------------|
| 1RXSJ022716.6+020154        | 0.457     | 0.83     | 18.9 | Ca II   | 5731      | 0.457 | g    | 1000 | +1.6|                |
|                             |           |          |      | G band  | 6277      | 0.458 | g    | 900  | +1.3|                |
| PKS 0306+102                | 0.862     | 0.47     | 21.2 | C II    | 4332      | 0.862 | e    | 1800 | −10 | 15.6           |
|                             |           |          |      | Mg II   | 5210      | 0.862 | e    | 2400 | −35 | 40.7           |
|                             |           |          |      | [Ne V]  | 6376      | 0.862 | e    | 600  | −1  | 4.9            |
|                             |           |          |      | [O II]  | 6938      | 0.862 | e    | 500  | −5  | 5.0            |
|                             |           |          |      | [Ne III] | 7202     | 0.862 | e    | 800  | −6  | 1.9            |
| 1RXSJ031615.0−260748        | 0.443     | 1.20     | 18.1 | [O II]  | 5377      | 0.443 | e    | 1500 | −0.6| 1.2            |
|                             |           |          |      | Ca II   | 5678      | 0.443 | g    | 2200 | +0.6|                |
|                             |           |          |      | Ca II   | 5724      | 0.442 | g    | 1500 | +0.6|                |
|                             |           |          |      | G band  | 6213      | 0.443 | g    | 1200 | +0.6|                |
| PKS 0338−214                | 0.223     | 0.27     | 17.9 | [O II]  | 4560      | 0.223 | e    | 4700 | −0.6| 0.63           |
|                             |           |          |      | [O III] | 6074      | 0.224 | e    | 2400 | −1.8| 0.52           |
| PKS 0426−380                | 1.105     | 0.70     | 18.6 | C III]  | 4006      | 1.098 | e    | 3000 | −3.6| 47.7           |
|                             |           |          |      | Mg II   | 5908      | 1.112 | e    | 4700 | −5.7| 71.8           |
|                             |           |          |      | [O II]  | 7826      | 1.099 | e    | 1000 | −1.2| 16.2           |
|                             |           |          |      | MgII    | 4362      | 0.559 | a    | 1200 | +2.2|                |
|                             |           |          |      | MgII    | 5681      | 1.030 | a    | 1500 | +2.3|                |
| 1RXSJ055806.6−383829        | 0.302     | 1.21     | 16.8 | Ca II   | 5120      | 0.301 | g    | 1400 | +0.9|                |
|                             |           |          |      | Ca II   | 5169      | 0.302 | g    | 1400 | +0.8|                |
|                             |           |          |      | G band  | 5605      | 0.302 | g    | 1800 | +0.7|                |
|                             |           |          |      | Mg I    | 6735      | 0.302 | g    | 1600 | +0.8|                |
| PKS 0808+019                | 1.148     | 0.93     | 18.4 | C III]  | 4099      | 1.147 | e    | 4200 | −2.8| 31.0           |
|                             |           |          |      | Mg II   | 6014      | 1.149 | e    | 5400 | −5.1| 28.34          |
| 1WGAJ1012.2+063             | 0.727     | 0.80     | 17.6 | Mg II   | 4838      | 0.729 | e    | 2000 | −0.6| 5.3            |
|                             |           |          |      | [O II]  | 6434      | 0.726 | e    | 2100 | −0.6| 4.9            |
|                             |           |          |      | MgII    | 4246      | 0.518 | a    | 1400 | +1.2|                |
| PKS 1250−33                 | 0.856     | 0.48     | 20.1 |        |           |      |      |      |     |                |
Table 2—Continued

| Object name | \( z_{\text{avg}} \) | \( \alpha \) | V | Line ID | \( \lambda \) | \( z \) | Type | FWHM | EW | Line luminosity |
|-------------|----------------|-------|---|--------|-------------|-----|------|-------|----|----------------|
| PKS 1256−229 | 0.481 | 0.31 | 17.9 | Mg II | 5192 | 0.856 | e | 4200 | −20.8 | 17.8 |
| [O II] | 5521 | 0.481 | e | 1200 | −1.5 | 4.6 |
| [O III] | 7417 | 0.481 | e | 500 | −0.7 | 1.5 |
| PKS 1519−273 | 1.297* | 0.51 | 17.8 | Mg II | 6427 | 1.297 | e | 1900 | −1.4 | 23.3 |
| PKS 2354−021 | 0.812* | 0.67 | 20.4 | Mg II | 5071 | 0.812 | e | 6100 | −5.3 | 5.8 |

Note. — Description of columns: (1) Name of the source; (2) average of redshift from the single lines; (3) spectral \( \alpha \) index of the continuum, defined by \( F_\lambda \propto \lambda^{-\alpha} \); (4) V magnitude estimated from observed spectra; (5) line identification; (6) observed wavelength of line center (Å); (7) redshift of the line; (8) type of the line (e: emission line; g: absorption line from the host galaxy; a: absorption line from intervening systems); (9) FWHM of the line (km s\(^{-1}\)); (10) EW of the line (Å); (11) emission line luminosity (10\(^{41}\) erg s\(^{-1}\)). *: tentative redshift estimate, obtained assuming that the only detected emission feature is MgII 2798 Å.