

## SPECTROSCOPY OF 10 $\gamma$ -RAY BL LAC OBJECTS AT HIGH REDSHIFT

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### ABSTRACT

We present high S/N optical spectra of 10 BL Lac objects detected at GeV energies by *Fermi* satellite (3FGL catalog), for which previous observations suggested that they are at relatively high redshift. The new observations, obtained at the 10 m Gran Telescopio Canarias, allowed us to find the redshift for J0814.5+2943 ( $z = 0.703$ ) and we can set spectroscopic lower limit for J0008.0+4713 ( $z > 1.659$ ) and J1107.7+0222 ( $z > 1.0735$ ) on the basis of Mg II intervening absorption features. In addition we confirm the redshifts for J0505.5+0416 ( $z = 0.423$ ) and for J1450+5200 ( $z > 2.470$ ). Finally we contradict the previous  $z$  estimates for five objects (J0049.7+0237, J0243.5+7119, J0802.0+1005, J1109.4+2411, and J2116.1+3339).

*Keywords:* BL Lac object spectroscopy — Redshift

### 1. INTRODUCTION

Blazars are active galactic nuclei (AGN) where the relativistic jet is pointing in the observer's direction. They are characterized by high variability in all bands, and large polarization. The spectral energy distribution (SED) exhibits two broad bumps, one in the IR-X-ray band, and one in the MeV-TeV band. The former is due to synchrotron radiation produced by the relativistic electrons in the jet, while the latter in most models is due to the Compton scattering of the same electrons (e.g. [Maraschi et al. 1992](#); [Dermer & Schlickeiser 1993](#); [Ghisellini & Tavecchio 2009](#)). In some cases the thermal contribution due to the AGN accretion disk is also visible (see e.g. [Madejski & Sikora 2016](#), for a recent review).

Blazars are usually divided in two classes, BL Lac Objects (BLLs) and Flat Spectrum Radio Quasars (FSRQs), depending on the strength of the broad emission lines with respect to the continuum. A more physical distinction refers to the comparison between the broad line region luminosity and the Eddington luminosity. FSRQs have radially efficient accretion disk, while BLLs are not able to photoionize gas in the clouds of the broad line region, explaining the lacking of these features in the majority of their spectra (e.g. [Ghisellini et al. 2017](#), and references therein). Note that this classification requires the knowledge of the mass of the accreting black hole,

and of the distance, which for broad emission line AGNs can be easily determined by spectroscopy. However, this becomes arduous for the BLLs due to the weakness of the spectral lines.

The advent of the *Fermi* gamma-ray observatory (1-100 GeV), starting observations in 2008 ([Atwood et al. 2009](#)), with its systematic scanning of the entire sky every 3 hours, has substantially modified the study of blazars, which previously was based mostly on radio and X-ray surveys. In fact it was shown that blazars dominate the extragalactic gamma-ray sky ([Stephens et al. 2015](#)). The third AGN FERMI/LAT catalogue (3LAC, [Ackermann et al. 2015](#)) contains 1738 blazars, compared with the  $\sim 3000$   $\gamma$ -ray detected sources, where 662 are classified as BLL and 491 as FSRQ. The remaining blazars are reported as of uncertain type.

It is worth to note that for a large fraction of the BLLs the redshift is still unknown or highly uncertain. Based on the present statistics it was nevertheless proposed that on average BLLs have lower redshift and smaller high energy (HE;  $> 20$ MeV)  $\gamma$ -ray luminosity than FSRQs ([Ghisellini et al. 2017](#)). This proposal, however, could be biased since at high redshift the number of robustly detected BLLs is drastically reduced due the difficulty of measuring the redshift (e.g. [Falomo et al. 2014](#), and references therein). Moreover the uncertainty of the redshift hampers to perform a sound comparison of the characteristics of the multiwavelength SED

between the two classes of blazars for which both the bolometric luminosity and redshift are needed (see the so-called *blazar sequence*, [Fossati et al. 1998](#)).

The determination of the redshift of BLLs is also important to characterize the properties of the extra galactic background light (EBL, e.g. [Franceschini et al. 2008](#), and references therein). The Very High Energy sky (VHE;  $> 100$  GeV), observed with Cherenkov telescopes, is mainly dominated by BLLs (in the TeVcat<sup>1</sup> there are 60 BLLs against 6 FSRQs). Their energetic  $\gamma$ -rays can interact with IR-optical EBL photons to produce  $e^-/e^+$  pairs, resulting in a clearly detectable absorption in the GeV-TeV BLL spectrum starting at frequencies and with optical depth that depend on the redshift of the  $\gamma$ -ray source and is more pronounced in the  $0.5 < z < 2$  interval. At higher  $z$  the absorption due to pair production moves to *Fermi* energies, completely extinguishing the source in the VHE regime. Although a significant number of FSRQ detections, up to  $z > 4$  already exist ([Ackermann et al. 2017](#)), at the TeV energies, due to their Compton inverse peak position, only a small fraction of them are detected. Therefore the identification of high redshift<sup>2</sup> BLLs at these energies is particularly challenging in order to study the earliest EBL components due to the first-light sources (Population III stars, galaxies or quasars) in the universe ([Franceschini & Rodighiero 2017](#)).

In the framework of our long-term optical spectroscopy program at large (8 - 10 m) telescopes, aimed at determining the redshift of the BLLs ([Sbarufatti et al. 2005, 2006; Sandrinelli et al. 2013; Landoni et al. 2012, 2013, 2014, 2015; Paiano et al. 2016, 2017](#)), we concentrate here on 10 BLLs detected by *Fermi* satellite with unknown or very uncertain redshift.

In this work we assume the following cosmological parameters:  $H_0 = 70$  km s<sup>-1</sup> Mpc<sup>-1</sup>,  $\Omega_\Lambda=0.7$ , and  $\Omega_m=0.3$ .

## 2. SAMPLE, REDUCTION AND DATA ANALYSIS

We searched for BLLs that are candidates for being at high redshift ( $z > 1$ ) in the *Fermi* 3LAC catalog. These objects have uncertain redshift and, in most cases, conflicting values are reported in the literature mainly due to low S/N spectra. Considering only the sources that are well observable from La Palma site the selection produced 18 targets and we obtain observations for 10 of them (see Table 1).

The observations were gathered in Service Mode at the GTC using the low resolution spectrograph OSIRIS ([Cepa et al. 2003](#)). The instrument was configured

with the grisms R1000B and R1000R<sup>3</sup>, in order to cover the whole spectral range 4100-10000 Å, and with a slit width = 1" yielding a spectral resolution  $\lambda/\Delta\lambda = 800$ .

For each grism, we obtained three individual exposures (with exposure time ranging from 150 to 1200 seconds each, depending on the source magnitude), which were combined into a single average image, in order to perform an optimal cleaning of cosmic rays and CCD cosmetic defects. Wavelength calibration was performed using the spectra of Hg, Ar, Ne, and Xe lamps and providing an accuracy of 0.1 Å over the whole spectral range. For each object the spectra obtained with the two grisms were merged into a final spectrum covering the whole desired spectral range. Spectra were corrected for atmospheric extinction using the mean La Palma site extinction table<sup>4</sup>. Relative flux calibration was provided by spectro-photometric standard stars secured during the same nights of the target exposure. The observation strategy and the data reduction followed the same procedure reported in the [Paiano et al. \(2017\)](#) and detailed information on the observations are given in Table 2.

## 3. RESULTS

The optical spectra of the targets are presented in Fig. 1. In order to emphasize weak emission and/or absorption features, we show also the normalized spectrum. This was obtained by dividing the observed calibrated spectrum by a power law continuum fit of the spectrum, excluding the telluric absorption bands (see Tab. 3). The normalized spectra were used to evaluate the signal-to-noise ratio (S/N) in a number of different spectral regions. On average, the S/N ranges from 10 to 200 depending on the wavelength and the magnitude of the source (Tab. 3). These spectra can be accessed at the website <http://www.oapd.inaf.it/zbllac/>.

All spectra were carefully inspected to find emission and absorption features. When a possible feature was identified, we determined its reliability checking that it was present in the three individual exposures (see Sec. 2 for details).

We were able to detect stellar spectral features of Ca II (3934,3968) for 3FGL J0505.5+0416 and 3FGL J0814.5+2943. For two sources, 3FGL J0008.0+4713 and 3FGL J1107.5+0222, we detect strong intervening absorption system due to Mg II (2800), allowing to set a spectroscopic lower limit of their redshift. Finally in one object, 3FGL 1450.9+5200, we detect intervening absorption systems due to C IV (1548) and Ly $\alpha$  (1216) at two different redshifts. For five other objects the spectrum

<sup>1</sup> <http://tevcad.uchicago.edu/>

<sup>2</sup> Few known redshifts of BLLs range between 0.5 and 2.5.

<sup>3</sup> <http://www.gtc.iac.es/instruments/osiris/osiris.php>

<sup>4</sup> <https://www.ing.iac.es/Astronomy/observing/manuals/>

appears featureless in contrast with the previous claimed redshift values. Details are reported in Fig. 2 and in Tab. 4.

Starting from the basic assumption that all BLLs are hosted by a massive elliptical galaxy, one is able to detect faint absorption features from the starlight provided that the S/N and the spectral resolution are sufficiently high. According to the scheme outlined in Paiano et al. (2017), in the case of no detection of spectral features it is also possible to set a lower limit to the redshift based on the minimum Equivalent Width (EW) spectrum (see Appendix A of Paiano et al. 2017, for details). The results about the redshift lower limits obtained for the whole sample are summarized in Table 3 and details about the optical spectra and redshift estimates for each individual object of our sample are given in Sec. 4.

#### 4. NOTES FOR INDIVIDUAL SOURCES

**3FGL J0008.0+4713:** From an optical spectrum provided by Kock et al. (1996), a redshift of 0.28 was proposed, from absorption features of its host galaxy (the spectrum is not published). However, the object appears unresolved from optical images (Nilsson et al. 2003). A more recent and rather noisy spectrum from Shaw et al. (2013) gives a tentative high redshift  $z = 2.1$ , based on the onset of the Lyman- $\alpha$  forest. In our spectrum we clearly detect an intervening absorption doublet at 7440 Å (see Table 4) that we identify with Mg II (2800) at  $z = 1.659$ . No other emission or absorption features are found. The continuum is well fitted by a power law with the rather flat spectral index ( $\alpha = +0.74$ ,  $F_\nu \propto \nu^\alpha$ ), suggesting dust extinction possibly associated to intervening gas at  $z = 1.659$ . This target is therefore one of the highest redshift BLL known thus far.

**3FGL J0049.7+0237:** First optical spectrum was secured by Dunlop et al. (1989) finding the source featureless. Same result was obtained few years later by Allington-Smith et al. (1991). A superior quality optical spectrum was then published by Sbarufatti et al. (2006), that confirm the featureless spectrum of the source, while Shaw et al. (2013) claim the detection of the broad emission at  $\sim 6930\text{Å}$  identified as Mg II (2800), suggesting  $z = 1.474$ . From our spectrum (S/N  $\sim 100$ ), we contradict the presence of the above feature, therefore the redshift is still unknown. We set a lower limit based on the non-detection of the starlight (see Sec. 3) of  $z > 0.55$ .

**3FGL J0243.5+7119 :** A featureless optical spectrum was reported by Stickel & Kuehr (1996). A possible intervening absorption of Mg II (2800)

at 5595 Å is claimed by Shaw et al. (2013) yielding a redshift limit of  $z > 1$ . We do not confirm this absorption doublet in our spectrum and note that at this wavelength there is a very strong night sky emission. We also note that this source is at low galactic latitude ( $b=10^\circ$ ) and therefore the source is severely absorbed ( $E(B-V) = 0.7$ ). We set a lower limit of  $z > 0.45$  based on lack of starlight features.

**3FGL J0505.5+0416:** This is a radio source (Bennett et al. 1986; Bauer et al. 2000) well-detected at X-ray and gamma-ray frequencies (Voges et al. 1999; Acero & Fermi-LAT Collaboration 2015). The first optical spectrum is reported in Laurent-Muehleisen et al. (1998) that fails to detect any lines. Optical images, obtained by Nilsson et al. (2003), were able to resolve the host galaxy, indicating a relatively low redshift. The optical spectrum obtained by Pita et al. (2014) shows absorption features of the host galaxy yielding a redshift of 0.424. We confirm the Ca II doublet (3934, 3968), which in the Pita et al. spectrum was in the merging region of the UVB and VIS arm of the instrument, and we also detect the absorption line due to the G-band (4305) at  $z = 0.423$  (see Fig. 2).

**3FGL J0802.0+1005:** The object was identified as a BLL by Plotkin et al. (2010) on the basis of the SDSS spectrum, and it is not yet detected in the X-ray band and the counterpart is very faint in the radio regime (Condon et al. 1998). It was observed twice by SDSS and two different redshifts were proposed from the automatic line identification ( $z = 0.06$  and  $z = 0.842$ ). From our visual inspection of these two spectra, no significant presence of emission or absorption lines are seen. Our optical spectrum confirms the featureless continuum described by a power law of  $\alpha = -0.77$  and we can set a relatively high redshift limit of  $z > 0.58$ .

**3FGL J0814.5+2943:** White et al. (2000) found a featureless optical spectrum. In our high S/N $\sim 160$ , we detect an absorption doublet system at 6699-6759 Å that we identify as Ca II at  $z = 0.703$  from the starlight of the host galaxy (see Fig. 2). We note that the redshift value reported by NED ( $z = 1.083$ ) based on the SDSS spectrum is contradicted by our spectrum.

**3FGL J1107.5+0222:** In Plotkin et al. (2010), the authors found a featureless optical spectrum based on SDSS data. We clearly detect an absorption doublet at 5797,5812 Å that we identify with

Mg II (2800) intervening system at  $z = 1.0735$  (see Fig. 2).

**3FGL J1109.4+2411:** The source was discovered and identified as a BLL from X-ray Einstein Sky Survey (Perlman et al. 1996). The host galaxy was detected from images by HST snapshots suggesting a redshift  $z \sim 0.5$  (Sbarufatti et al. 2005; Falomo & Kotilainen 1999; Sbarufatti et al. 2005). The optical spectrum obtained by SDSS is found featureless<sup>5</sup> (Shaw et al. 2013) and also an ESO VLT spectrum reported by Landoni et al. (2013) appears featureless. We obtain an optical spectrum with a S/N ranging from 20 to 70, and no significant emission or absorption lines are detected with a minimum EW of  $\sim 0.35 \text{ \AA}$  that allows to set a redshift lower limit of  $> 0.5$ .

**3FGL J1450.9+5200:** The source was proposed as a very high redshift BLL by Plotkin et al. (2010) on the basis of intervening absorption of C IV(1548) and  $\text{Ly}_\alpha$  (1216) in the SDSS spectrum at redshift of  $z = 2.474$ . We also detect the presence of the absorption line at  $5372 \text{ \AA}$  identified as C IV (1548) intervening gas, and at the same redshift we see a strong  $\text{Ly}_\alpha$  (1216) absorption. In addition, we find an absorption feature at  $5127 \text{ \AA}$  that we interpret as a second C IV (1548) intervening system at  $z = 2.312$ . Finally other absorption lines due to  $\text{Ly}_\alpha$  are observed at  $\lambda < 4219 \text{ \AA}$ . The redshift of this source is thus  $z > 2.474$ .

The source is detected by *Fermi* up to the 60-80 GeV interval (The Fermi-LAT Collaboration 2017). The optical depth at  $z = 2.470$  for pair production in the EBL is  $\tau \sim 1$  (see Fig. 10 of Franceschini et al. 2017, in press).

**3FGL J2116.1+3339:** The source was originally detected in the radio-band (B 2114+33) and it appears in ROMA BZCAT (BZB J2116+3339 Masaro et al. 2015), which reports a radio, optical (R=15.4), X-ray, and gamma-ray flux. An optical spectrum is given by Shaw et al. (2013) which to us appears featureless, although the authors claim a redshift of 1.596 based on a very dubious extremely faint C IV (1548) emission. In contrast in our spectrum we do not detect any emission or absorption lines with  $\text{EW} > 0.30 \text{ \AA}$  and we set a redshift lower limit of  $> 0.25$ .

## 5. CONCLUSION

The discovery of hundreds of BLLs by the *Fermi* satellite motivates accurate optical spectroscopic studies, which in most cases require the use of large telescopes. In fact, the information on the redshift derives from the detection of very weak absorption or emission lines, at the source or in the intervening material. Our paper has focused on 10 sources detected at GeV energies, for which we present spectra of very good quality with S/N values ranging up to  $\sim 200$ . They were chosen among objects already observed with smaller telescopes or with a poor S/N spectrum and there was some indication that they were at relatively high  $z$ . For five out of 10 sources studied, spectral features were detected, while for the rest the only information on the redshift is a lower limit based on the absence of absorption lines from the host galaxy. For 8 out of the 10 sources the redshifts are above 0.5, and two of them are two of the farthest BLLs known till now, 3FGL J0008.0+4713 ( $z > 1.659$ ) and 3FGL J1450.9+5200 ( $z > 2.470$ ). In spite of the improvement of the observing facilities (large telescope and modern instrumentation), the redshift determination of some high redshift BLLs remains rather arduous. However its knowledge is crucial for the advancing of our understanding of BLLs in a cosmic context.

<sup>5</sup> the SDSS automatic line identification gives  $z=1.22$

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**Table 1.** THE SAMPLE OF 3FGL/LAC BL LAC OBJECTS

3LAC name	Other name	RA (J2000)	$\delta$ (J2000)	V	$E(B - V)$ ( <i>degree</i> )	tentative redshifts
3FGL J0008.0+4713	BZB J0007+4712	00:08:00.0	+47:12:08	18.30	0.08	0.28 , 2.10
3FGL J0049.7+0237	PKS 0047+023	00:49:43.2	+02:37:04	18.00	0.01	1.44 , 1.474
3FGL J0243.5+7119	BZB J0243+7120	02:43:30.9	+71:20:18	19.20	0.70	>0.998, ?
3FGL J0505.5+0416	BZB J0505+0415	05:05:34.8	+04:15:55	16.70	0.07	0.424 , ?
3FGL J0802.0+1005	BZB J0802+1006	08:02:04.8	+10:06:37	17.42	0.02	0.842, ?
3FGL J0814.5+2943	EXO 0811+2949	08:14:21.3	+29:40:21	18.80	0.03	1.084
3FGL J1107.5+0222	BZB J1107+0222	11:07:35.9	+02:22:25	18.97	0.03	?
3FGL J1109.4+2411	1ES 1106+244	11:09:16.1	+24:11:20	18.70	0.02	0.482, 1.221
3FGLJ1450.9+ 5200	BZB J1450+5201	14:50:59.9	+52:01:11	18.90	0.02	2.471, 2.474
3FGL J2116.1+3339	2FGL J2116+3339	21:16:14.5	+33:39:20	16.30	0.10	0.35 , 1.596

Col.1: 3FGL/LAC name of the target; Col.2: Other name of the target; Col.3: Right Ascension; Col.4: Declination; Col.5: V-band magnitudes taken from NED; Col.6:  $E(B - V)$  taken from the NASA/IPAC Infrared Science Archive (<https://irsa.ipac.caltech.edu/applications/DUST/>); Col.7: Tentative redshift taken from the literature. For references see Plotkin et al. (2010); Shaw et al. (2013), 3LAC catalog (Ackermann et al. 2015), and NED.

**Table 2.** LOG OF GTC OBSERVATIONS OF 3FGL/LAC BL LAC OBJECTS

Obejct	Grism B				Grism R			
	$t_{Exp}$ (s)	Date	Seeing (")	r	$t_{Exp}$ (s)	Date	Seeing (")	r
3FGL J0008.0+4713	1800	2015 Oct 04	1.5	18.4	1800	2015 Nov 23	2.0	18.5
3FGL J0049.7+0237	3600	2015 Nov 23	1.5	18.5	3600	2015 Nov 23	1.9	18.5
3FGL J0243.5+7119	3600	2015 Nov 20	1.6	18.9	2700	2015 Nov 20	2.2	18.9
3FGL J0505.5+0416	3600	2016 Feb 05	1.1	16.9	3600	2016 Feb 05	1.1	16.9
3FGL J0802.0+1005	2100	2016 Jan 28	1.3	18.5	2100	2016 Jan 28	1.3	18.5
3FGL J0814.5+2943	3600	2016 Feb 06	1.3	18.3	3600	2016 Feb 06	1.3	18.3
3FGL J1107.5+0222	3000	2015 Dec 23	1.6	18.3	3000	2015 Dec 23	1.9	18.3
3FGL J1109.4+2411	3600	2016 Jan 28	1.0	17.8	3600	2016 Jan 21	0.9	18.0
3FGL J1450.9+5200	1500	2015 Mar 14	2.2	18.4	1800	2015 Mar 14	2.1	18.4
3FGL J2116.1+3339	450	2015 Dec 24	1.9	16.7	450	2015 Dec 24	1.9	16.7

Col.1: Name of the target; Col.2: Total integration time with the Grism B; Col.3: Date of Observation with Grism B; Col.4: Seeing during the observation with the Grism B; Col.5: r ABmag measured on the acquisition image for the Grism B; Col.6: Total integration time with the Grism R; Col.7: Date of Observation with Grism R; Col.8: Seeing during the observation with the Grism R; Col.9: r ABmag measured on the acquisition images for the Grism R.

**Table 3.** PROPERTIES OF THE OPTICAL SPECTRA OF 3FGL/LAC SOURCES

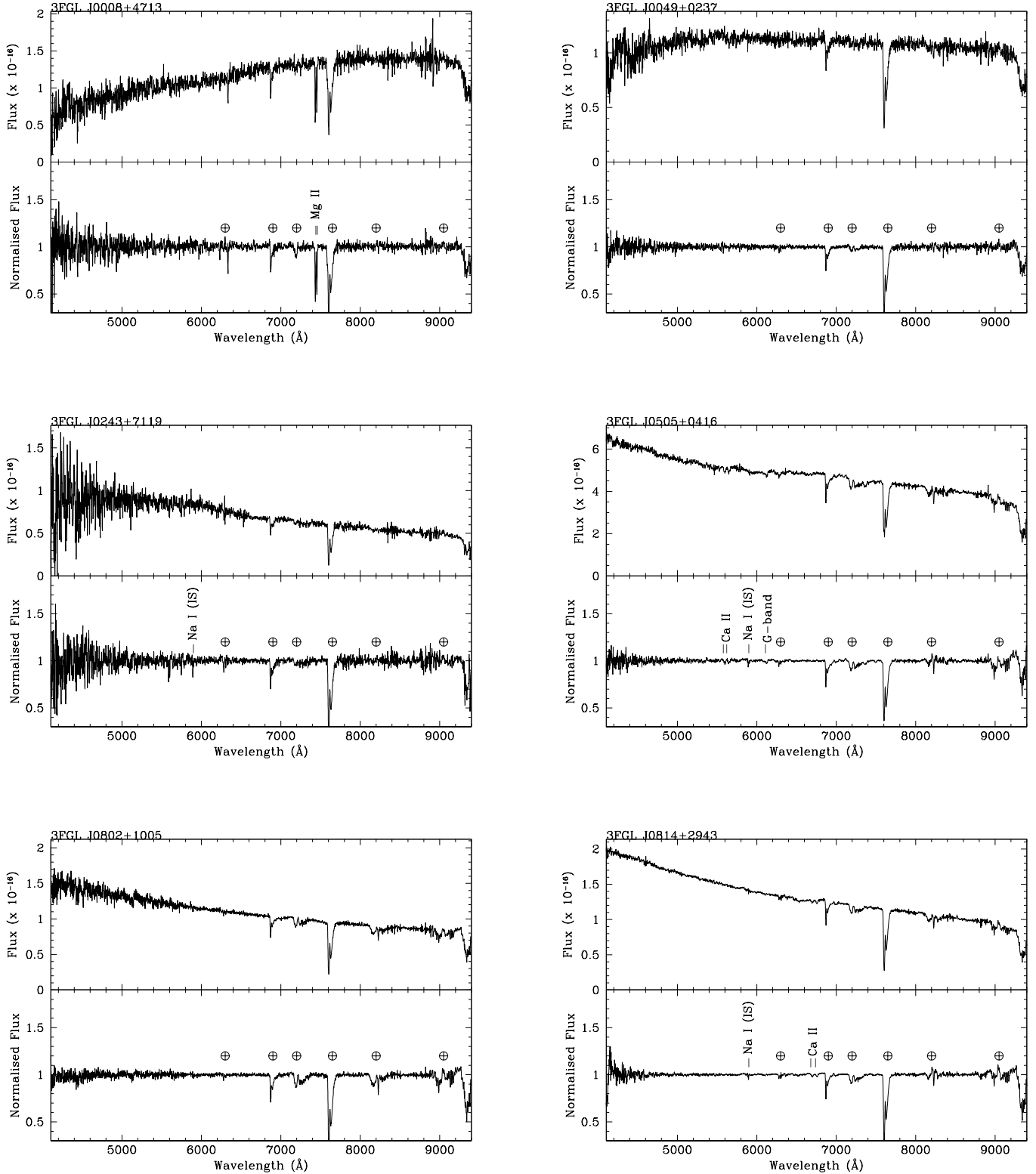
OBJECT	$\alpha$	SNR	$EW_{min}$	$z$
3FGL J0008.0+4713	+0.74*	10 - 50	0.50 - 3.10	$> 1.659^i$
3FGL J0049.7+0237	-0.01	27 - 95	0.30 - 1.20	$> 0.55^l$
3FGL J0243.5+7119	-0.95	10 - 65	0.45 - 3.25	$> 0.45^l$
3FGL J0505.5+0416	-0.62	40 - 150	0.15 - 0.65	$0.423^g$
3FGL J0802.0+1005	-0.77	32 - 108	0.30 - 0.70	$> 0.58^l$
3FGL J0814.5+2943	-0.95	54 - 161	0.20 - 0.55	$0.703^g$
3FGL J1107.5+0222	-0.82	27 - 208	0.15 - 1.15	$> 1.0735^i$
3FGL J1109.4+2411	-0.50	22 - 71	0.35 - 1.15	$> 0.50^l$
3FGL J1450.9+5200	-0.73	32 - 119	0.25 - 1.00	$> 2.470^i$
3FGL J2116.1+3339	-1.66	40 - 130	0.30 - 0.85	$> 0.25^l$

Col.1: Name of the target; Col.2: Optical spectral index derived from a power law fit in the range 4250-10000; Col.3: Range of S/N of the spectrum; Col.4: Range of the minimum equivalent width ( $EW_{min}$ ) derived from different regions of the spectrum (see text), Col.5: Proposed redshift from this work. The superscript letters indicate  $g$  = host galaxy absorption,  $i$  = intervening absorption,  $l$  = lower limit of the redshift by assuming a BL Lac host galaxy with  $M_R = -22.9$

**Table 4.** MEASUREMENTS OF SPECTRAL LINES

OBJECT	$\lambda_{obs}$ Å	EW (observed) Å	Line ID	$z_{line}$
3FGL J0008.0+4713	7434.94	5.3	Mg II (2796)	1.659
	7454.20	4.2	Mg II (2803)	1.659
3FGL J0505.5+0416	5598.08	0.8	Ca II (3934)	0.423
	5646.46	0.6	Ca II (3968)	0.423
	6126.02	0.7	G-band (4305)	0.423
3FGL J0814.5+2943	6699.60	0.6	Ca II (3934)	0.703
	6757.50	0.5	Ca II (3968)	0.703
3FGL J1107.5+0222	5797.50	2.0	Mg II (2796)	1.0735
	5812.02	1.9	Mg II (2803)	1.0735
3FGL J1450.9+5200	4219.69	5.8	Ly $\alpha$ (1216)	2.470
	5127.64	1.1	C IV (1548)	2.312
	5372.25	3.2	C IV (1548)	2.470

Col.1: Name of the target; Col.2: Barycenter of the detected line (the superscript letter  $a$  indicate absorption line); Col.3: Measured equivalent width; Col.4: Line identification; Col.5: Spectroscopic redshift.



**Figure 1.** Spectra of the high redshift 3FGL/LAT BLLs obtained at GTC. *Top panel:* Flux calibrated and dereddered spectra. *Bottom panel:* Normalized spectra. The main telluric bands are indicated by  $\oplus$ , the absorption features from interstellar medium of our galaxies are labelled as IS (Inter-Stellar). Data available at URL: <http://www.oapd.inaf.it/zbllac/>.



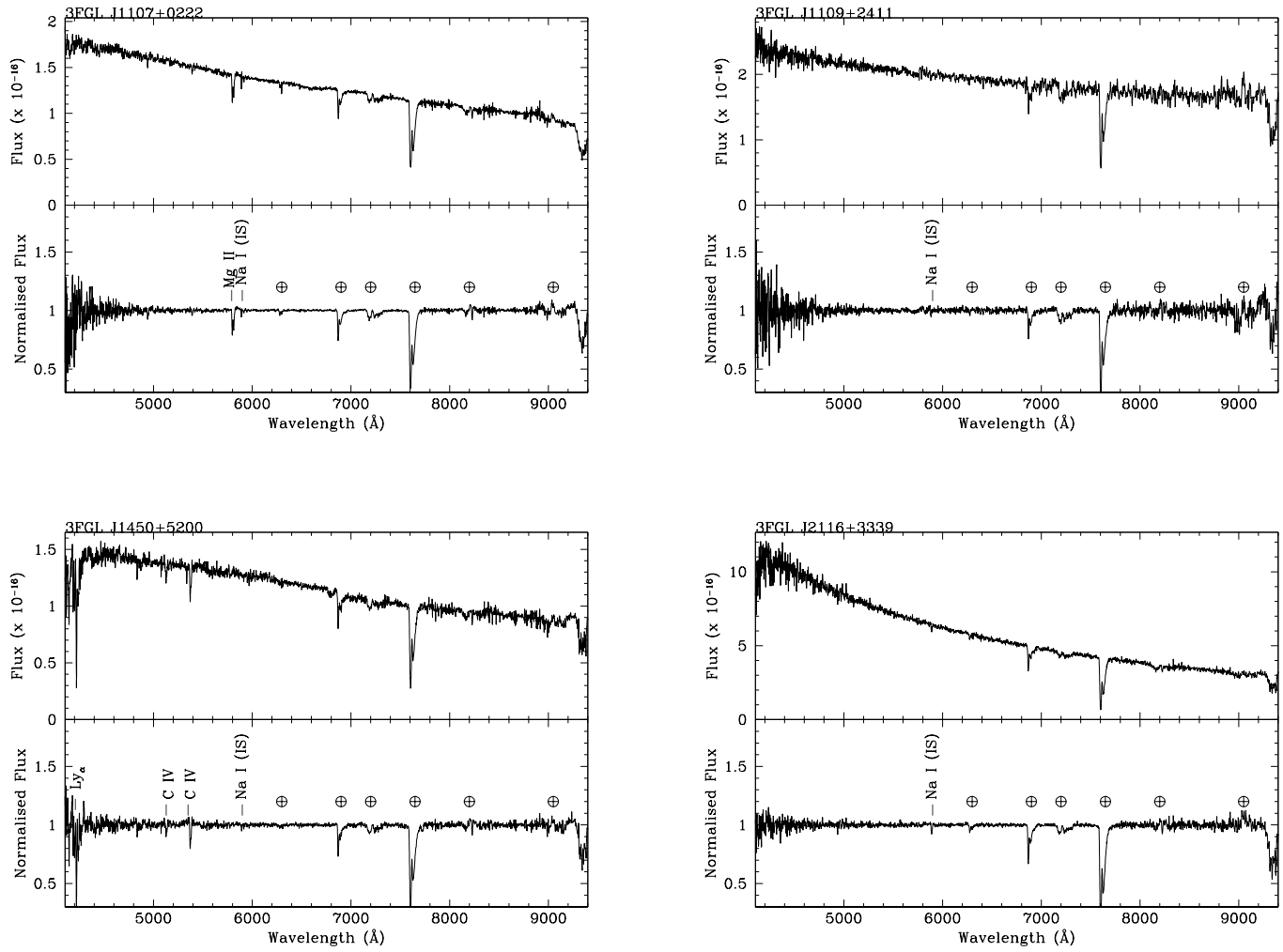
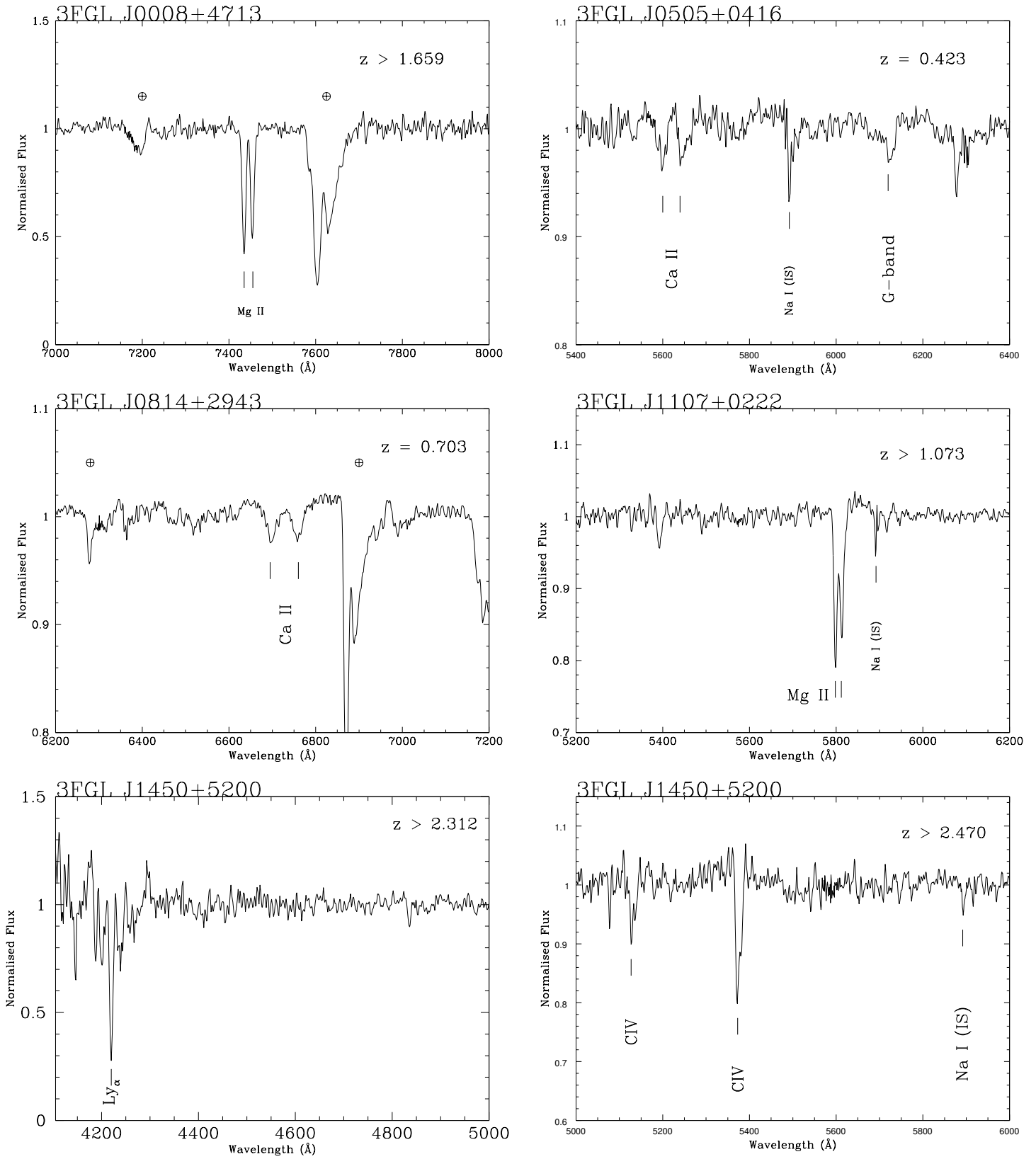


Figure 1. Continued. Data available at URL: <http://www.oapd.inaf.it/zbillac/>



**Figure 2.** Close-up of the normalized spectra around the detected spectral features of the high redshift 3FGL/LAT BLLs obtained at GTC. Main telluric bands are indicated as  $\oplus$ , spectral lines are marked by line identification.