Astron. Astrophys. 340, 381–383 (1998)

ASTRONOMY
AND
ASTROPHYSICS

Discovery of a $z = 0.808$ damped Lyα system candidate in a UV selected quasar spectrum

V. Le Brun, M. Viton, and B. Milliard

IGRAP/Laboratoire d'Astronomie Spatiale du C.N.R.S., B.P. 8, F-13376 Marseille, France (e-mail: vlebrun, mviton, bmilliard@astrsp-mrs.fr)

Received 8 April 1998 / Accepted 21 August 1998

Abstract. We present the observation of a new intermediate redshift damped Lyα absorption system candidate, discovered in the course of a spectroscopic follow-up for identifying the sources detected in a 150Å-wide bandpass UV-imaging survey at 2000 Å. The system displays very strong Mg II and Fe II lines and a high Fe II/Mg II ratio, which, following photoionization models, indicates a very high neutral hydrogen column density. Such systems being very rare at redshifts ≤ 1.7, but of prime importance for the understanding of the evolution of star formation in galaxies, the newly discovered candidate deserves further investigation in a near future.

Key words: galaxies: abundances – galaxies: halos – galaxies: ISM – galaxies: quasars: absorption lines – galaxies: quasars: individual: Q D089/898

1. Introduction

The damped Lyα Absorption Systems (DLAS), detected in the spectra of high redshift quasars are characteristic of large neutral hydrogen column densities, and were first thought to arise in protogalactic disks (Wolfe et al. 1986). This vision has recently evolved with the detection of low redshift systems for which optical identification of the absorber could be performed (Steidel et al. 1994, Le Brun et al. 1997, Rao & Turnshek 1998). It appears in fact that all morphological types of galaxies are likely to give rise to such absorptions, and it becomes possible to study in detail the characteristics of the interstellar medium of these galaxies (absorption line analysis gives information on metallicity, ionization level, velocity structure...), coupled to their morphological type. Therefore, these DLAS are very powerful tools for studying the evolution of galaxies as regards the gaseous content, metallicity and star formation history: the absorbing gas detected in the galaxies is at the origin of stars, and the evolution of its amount gives clues for star formation rate estimates vs. cosmic time (see e.g Lanzetta et al. 1995).

However, in the redshift interval $z < 1.7$ (which covers up to 77% of the age of the Universe), only very few DLAS are known: 1 from the HST "QSO Absorption Lines Key Project" (Jannuzi et al. 1998), 2 from the IUE QSO survey (Lanzetta et al. 1995), and 7 inferred from the properties of metal lines and/or 21 cm absorption, and confirmed a posteriori with HST spectroscopy (Boissé et al. 1998). As a result of a HST UV spectroscopic survey of strong Mg II systems, Rao & Turnshek (1998) have increased the sample with 12 new absorbers, but there is anyway a clear need of more absorbers to sample correctly the full properties of the gas vs. galaxy morphological type, abundance, etc.

It as recently been shown that the presence of an absorbing galaxy close to a quasar sightline may induce a bias in the optical magnitude-limited samples of quasars (for example, the dust contained in the galaxy may lead to a substantial extinction of the quasar, Boissé et al. 1998), and it is therefore important to investigate different ways of selection for the quasars. In this context, we present our analysis of a UV-selected quasar spectrum displaying strong and partially resolved absorption lines by the MgII doublet at a redshift of $z_{\rm a} \simeq 0.808$.

Given the scarcity of so strong absorption features in known QSOs as mentioned above, we have searched successfully for other metal absorption lines. In this paper, we briefly present the available data in Sect. 2. Preliminary analysis of the properties of the absorption system is given in Sect. 3, leading to the conclusion that it is very likely a new candidate to the DLAS sample that consequently deserves further spectroscopic and imaging observations at higher resolution, and towards more UV wavelengths. We also emphasize the high efficiency of space UV experiments for identifying the $z \lesssim 1.5$ DLAS.

2. Presentation of the data

The new DLAS candidate has been identified thanks to the FOCA balloon-borne survey at 200 nm (see Milliard, Donas & Laget, 1991). This 40 cm telescope has been routinely flown over years and has revealed a large set of UV sources with monochromatic magnitudes $m_{200} \lesssim 18.5$. Most of them ($\simeq 70\%$) are extragalactic, as recently confirmed by a spectroscopic follow-up (Milliard et al. 1998), performed in the optical domain toward a high galactic latitude ($+53°$) field of 0.6 square degree including the extragalactic cluster Abell 2111 (A2111).

Optical spectroscopy of the FOCA's UV-detected candidates around A2111 has been carried out with the NORRIS multifiber

Send offprint requests to: V. Le Brun

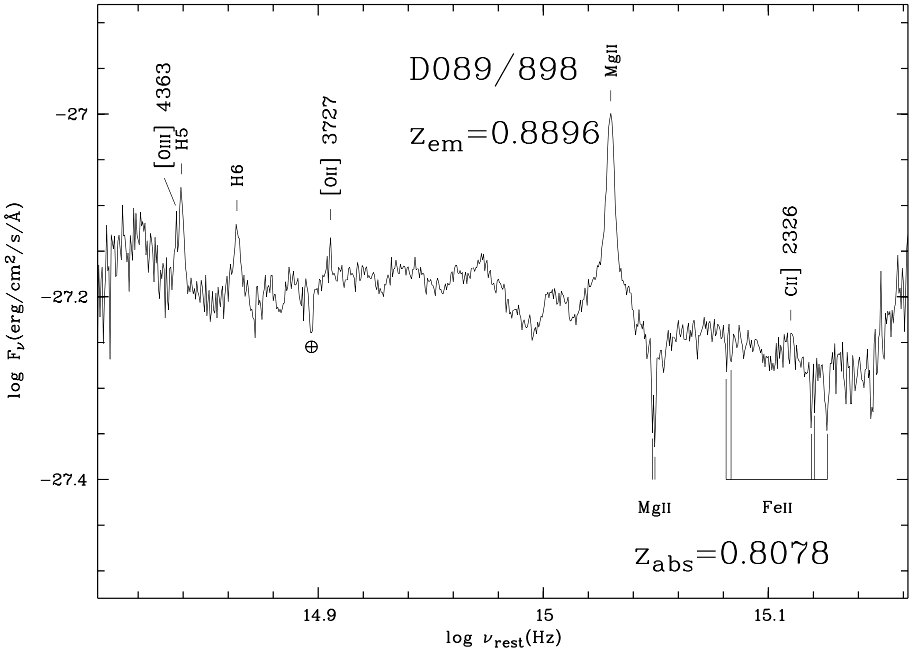

Fig. 1. Optical spectrum of QSO D089/898. The absolute flux calibration is based on the POSS2 B$\simeq 19.04$ magnitude value. The absorption lines listed in Table 1 are labelled.

Table 1. Absorption lines detected

$\lambda_{\rm obs}$(Å)	$W_{\rm obs}$(Å)[a]	Identification	z	$W_{\rm r}$
4236.7[b]	(0.7–0.9)	FeII 2343		
4291.48	0.72	FeII 2374	0.8079	0.4 ± 0.2
4306.44	1.26	FeII 2382	0.8079	0.7 ± 0.2
4676.57	(0.6–0.8)	FeII 2586	0.8085	
4699.38	(0.5–1.2)	FeII 2599	0.8070	
5053.71	2.43	MgII 2796	0.80784	1.3 ± 0.2
5067.00	2.05	MgII 2803	0.80789	1.1 ± 0.2

[a] All $W_{\rm obs}$ values measured at positions calculated using the mean redshift of 0.80787 adopted for the MgII doublet
[b] in unknown blend or anomalous noise trough

spectrograph (Hamilton et al., 1993) mounted at the Cassegrain f/16 focus of the Hale 5m telescope at Mount Palomar. A detailed description of the observations from 1995 through 1997, their calibration and methods of reduction will be given in a forthcoming paper (Milliard et al. 1998), but for the sake of clarity of the present paper let us just mention that the wavelength domain was $\simeq 3800 - 9000$ Å with a resolution varying from $\approx 7 - 12$ Å FWHM over the full CCD field, and normally two exposures of $50 - 60$ min were taken on the sky, each one being bracketed by 2 FeAr arc exposures for wavelength calibration, while flat-fielding was achieved using dome-flats.

Special attention was payed to the sky background subtraction, so critical in the infrared, and a relative flux calibration was provided by the very hot sdO standard BD$+28°4211$, while the continuous and selective atmospheric absorptions have been approximately corrected for, with satisfactory results in terms of spectral flux distribution over the full wavelength domain in most cases, and in particular for D089/898 as can be checked on Fig. 1.

Of the 113 field extragalactic objects spectroscopically observed around A2111, 8 are QSOs (previously unidentified) with redshifts in the range $0.8 \lesssim z \lesssim 1.5$. One of them is FOCA's id. number D089/898, a $B \simeq 19$ magnitude object that shows a strong, unresolved emission of the MgII 2796-2803 Å doublet at $z_{\rm e} \simeq 0.890$ (together with several weaker emission lines, see Fig. 1), but also partially resolved absorptions by the MgII doublet at a lower redshift of $z_{\rm a} \simeq 0.808$, and with rest equivalent widths $\gtrsim 1$ Å.

Notice that the only deep optical image presently available for this field is a B-band POSS2 image. With a limiting magnitude of 22, it is not deep enough neither for identifying the absorbing galaxy nor for constraining the brigthness.

3. Characteristics of the system

The absorption lines detected in the quasar spectrum are presented in Table 1. Besides the strong MgII doublet, several lines of FeII are the only other conspicuous features at our spectral resolution and S/N ratio. Upper limits on the strength of the MgI 2852 Å (0.6 Å) and CaII 3934 Å (0.3 Å) lines have also been estimated.

The strengths of the Mg II and Fe II lines strongly suggest the system is a DLAS. Photoionization models (Bergeron & Stasińska 1986), show that the presence of Fe II lines is a good indicator of high neutral hydrogen column densities, and that whenever the Fe II/Mg II ratio (measured by $W_{\rm r}$(Fe II 2382)$/W_{\rm r}$(Mg II 2796)) is greater than about unity, the absorber is very likely a strong DLAS (N(H I) $\gtrsim 2\,10^{20}$ cm^{-2}), where a Fe II/Mg II ratio greater than about 0.6 indicates a neutral hydrogen column density above 10^{20} cm^{-2} (Bergeron, private communication). The criterion has been successfully used by Wampler et al. (1993), and by Le Brun et al. (1997) to study the lower redshift DLAS, for which the Lyα line was in the UV

Table 2. Mg II and Fe II absorption lines in low redshift systems

Quasar	$z_{\rm d}$	Mg II		Mg I			Fe II			Fe II/Mg II
		2796	2804	2853	2344	2374	2382	2586	2600	
EX 0302-223	1.0095	0.88	0.86	0.17	–	–	–	0.57	0.62	0.70[a]
PKS 0454+039	0.8596	1.08	1.03	–	0.94	0.72	1.32	1.31	1.10	1.22
PKS 1229-021	0.3950	2.22	1.93	0.43	–	–	–	0.64	1.50	0.68[a]
3C 286	0.8490	0.65	0.51	0.44	0.17	0.29	0.38	0.47	0.36	0.58
Q 1209+107	0.6295	2.91	2.05	–	1.60	0.70	1.93	1.09	1.50	0.66
3C 196	0.4370	2.00	1.88	0.88	1.48	1.08	1.57	1.68	1.75	0.78
PKS 0118−272	0.558	0.49	0.46	0.16	0.27	0.16	0.34	0.26	0.36	0.70
D089/898	0.8078	1.34	1.13	–	–	0.40	0.70	–	–	0.52

[a] Fe II/Mg II ratio estimated from the Fe II 2600 line

range, and thus unobserved. In the $z_{\rm a} = 0.808$ absorber present in the spectrum of D089/898, we measure Fe II/Mg II $\simeq 0.52$, a value comparable to the lower limit inferred by Bergeron & Stasińska (1986) for the DLAS.

We have also listed in Table 2 the rest equivalent widths and the Fe II/Mg II ratio of the already known intermediate redshift DLAS, together with the candidate DLAS recently detected at $z = 0.558$ in the spectrum of PKS 0118-272 by Vladilo et al. (1997). As can be seen, the system discovered in the spectrum of D089/898 has line rest equivalent widths and a Fe II/Mg II ratio within the range of the other systems. All the confirmed systems have $N(\mbox{H I}) \geq 2\,10^{20}$ cm^{-2}, and the candidate DLAS in the spectrum of PKS 0118−272 displays Ca II and Ti II lines, which are only detected in DLAS. Taken all together, these facts indicate that the system detected in our UV-selected QSO spectrum is very likely a DLAS.

Because of the small size of the FOCA/NORRIS QSO sample, it is legitimate to address the questions of the probability to find such DLAS candidates, and of favorable effects possibly at play in our selection process. As a comparison, the HST/FOS Key Project did discover only one system among 35 quasars. But half of them have redshifts below 0.7 (of which 6 have $z \leq 0.3$), and thus the HST redshift path is very short. In contrast, the actual FOCA sample of QSOs around A2111 contains only 8 objects but with redshifts in the range $[0.8, 1.5]$. Given that i) the NORRIS spectroscopic observations allow to observe Mg II absorption lines with $z > 0.42$, yielding a cumulative redshift path in the FOCA sample of 5.45; and ii) the average number of DLAS at $\langle z \rangle = 0.64$ being $\langle n(z) \rangle = 0.083 \pm 0.046$ (Lanzetta et al. 1995), one expects to detect 0.63 ± 0.35 DLAS, a value compatible with our detection of one system. Indeed, it must be emphasized that compared to the HST/FOS Key Project, we are probing higher redshifts that give access to larger z paths in regions of higher DLAS density.

More generally, ground-based spectroscopic follow-up of VUV imaging surveys is an efficient way to discover DLAS candidates with measurable Lyα lines up to $z \simeq 1.7$, since the detection in a VUV bandpass picks up with a high probability QSOs that are bright enough in the region of the Lyα absorption line, including the scarce high redshift ones that are unaffected by the intergalactic Lyman continuum opacity (Møller & Jakobsen 1990). In this context, the GALEX project (planned for launch in 2001 as a NASA Small Mission Explorer) will provide a VUV survey quite suited to such a program in its imaging mode. In addition, with a spectroscopic mode that can by itself discover $z < 1.5$ DLAS from their Lyα line directly measured in the UV data, GALEX is expected to increase the present sample of known DLAS by an order of magnitude.

Acknowledgements. MV and BM wish to thank Chris Martin (PI on GALEX) for the opportunity of observing with NORRIS, together with the whole team at Palomar, and especially Todd Small (from Cambridge, UK) for his constant and efficient assistance during the observations.

References

Bergeron J., Stasińska G., 1986, A&A 169, 1
Boissé P., Le Brun V., Bergeron J., Deharveng J.M., 1998, A&A in press, astro-ph/9801146
Hamilton D., Oke J.B., Carr M.A., et al., 1993, PASP 105, 1308
Jannuzi B.T., et al., 1998, ApJS in press
Lanzetta K.M., Wolfe A.M., Turnshek D.A., 1995, ApJ 440, 435
Le Brun V., Bergeron J., Boissé P., Deharveng J.M., 1997, A&A 321, 733
Milliard B., Donas J., Laget M., 1991, Adv. Space Res. 11, 135
Milliard B., et al., 1998, ApJ in preparation
Møller P., Jakobsen P., 1990, A&A 228, 299
Rao S., Turnshek D., 1998, submitted to ApJ Letters
Steidel C.C., Pettini M., Dickinson M., Persson S.E., 1994, AJ 108, 2046
Vladilo G., Centurion M., Falomo R.; Molaro P., 1997, A&A 327, 47
Wampler E.J., Bergeron J., Petitjean P., 1993, A&A 273, 15
Wolfe A.M., Turnshek D.A., Smith H.E., Cohen R.S., 1986, ApJS 61, 249