Probing Galaxies through Quasar Absorption Lines
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O VI : nature and correlation with galaxies

Bastien Aracil[1], Todd M. Tripp[1] and David V. Bowen[2]

[1]University of Massachusetts, USA
[2]Princeton University Observatory, USA

Abstract. Deep galaxy redshift surveys in the field around sight lines that probe O VI absorbers is a powerful method to investigate the nature of these absorbers and their correlation with galaxies. Here we present preliminary results of a study of fields observed with the Gemini/GMOS spectrograph centred on three low redshift QSOs known to probe a variety of O VI systems. Notably, some O VI absorbers appear to be associated with isolated, individual galaxies. Others are clearly found within large-scale structures but at substantial distances from any individual galaxy.

1. Introduction

The study of O VI absorbers in quasar spectra at low redshift is particularly important since they may trace a warm-hot phase ($10^5 < T < 10^7$ K) of the intergalactic medium (IGM) that contains, according to numerical simulations, most of the baryons. Several works on O VI absorptions in quasar spectra at low redshift suggest that these absorbers are collisionally ionised and present a strong redshift correlation with the galaxies along the sight lines. However the nature of the O VI absorbers is still unclear: do they probe the ISM of an individual galaxy, the gas ejected by galactic winds, or large-scale structure of the IGM that is also traced by the galaxies? One way to gain some insight about the nature of the O VI absorbers and their correlation with galaxies is to perform a spectroscopic follow-up of the galaxies around sight lines known to probe a variety of O VI systems.

2. O VI systems and galaxy redshift surveys

The three quasars used for this study are PG1116+215, H1821+643, and PG0953+415 and their main characteristics are listed in Table 1. These sight lines have been previously observed with STIS and FUSE and studied by various teams (Ganuly *et al.* 2003, 2005; Savage *et al.* 2000, 2002; Sembach *et al.* 2004; Tripp *et al.* 1997, 1998a, 1998b, 2000). The significant number of O VI systems detected (17 in total) makes these three sight lines good candidates for our study.

The three fields have been observed with the Gemini/GMOS spectrograph. After reduction with the GMOS package of IRAF, we used the standard method of Tonry & Davis (1979) to determine the redshift of the galaxies by cross-correlation of the observed spectra with template spectra. The template spectra are high-S/N galaxy spectra from observations. We finally obtained the redshift of 213 galaxies (86, 81, and 46 in the field centred on H1821+643, PG0953+415, and PG1116+215 respectively) in a radius of 3 arc-min to the sight lines. This survey is expected to be complete down to a magnitude of $M_R \simeq 19$. We have also included galaxy redshifts from previous work (Tripp *et al.* 1998) to finally cover 0.5^o around each sight line.

Table 1. Main characteristics of the three quasars used for this study

Name	z_{em}	α	δ	M_R	No. of O VI systems Intervening (Total)
PG1116+215	0.1765	11 19 8.6	21 19 18	15.2	6 (8)
H1821+643	0.295	18 21 57.3	64 20 36	14.1	4 (6)
PG0953+415	0.2341	9 56 52.4	41 15 22	14.5	2 (3)

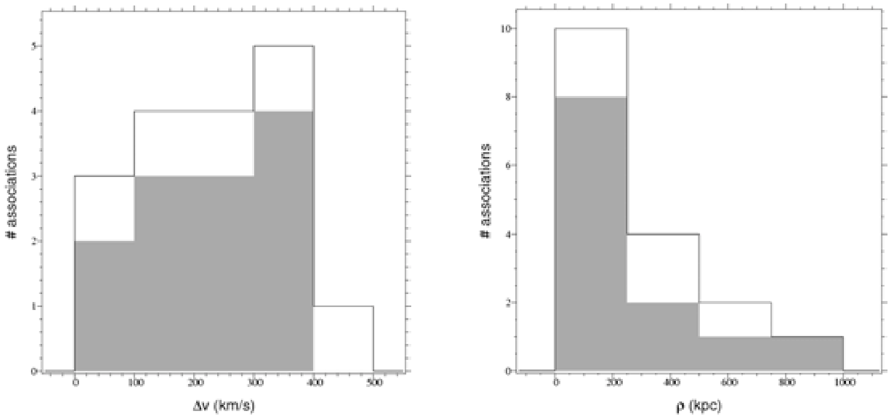

Figure 1. Distribution of the velocity separations and impact parameters of the galaxies/O VI absorbers associations. The associations were made by taking the closest galaxy to the sight line that is less than 500 km s^{-1} from the absorber. The grey part of the histograms corresponds to the intervening O VI and the clear part to the possible associated O VI.

3. Results and discussion

We have used two different methods to associate O VI absorbers and galaxies. The first method (method A), simply associates to an O VI system the closest galaxy that is less than 500 km s^{-1} from the absorber. The second method (method B), is based on the near-neighbour technique: a galaxy G and an absorber A form a pair if in velocity space G is the closest galaxy to A, and A is the closest absorber to G. In our study, the associations with the near-neighbour technique are almost the same as if we had associated to an absorber the closest galaxy in velocity that is at less than 2 Mpc. Each galaxy/absorber pair can then be characterised by their velocity separation and the impact parameter of the galaxy. Figs. 1 and 2 show the distribution of these two characteristics for all the associations and the two methods.

The right panel of Fig. 1 and the left panel of Fig. 2 present both a noticeable peak at low impact parameter ($\rho < 200$ kpc) and low velocity separation ($\Delta v < 100$ km s^{-1}) which could be interpreted as the signature of a correlation between O VI absorbers and galaxies. But the peak at low impact parameter arises when the pairs form in physical space (method A), and the one at low velocity separation when the associations are made in velocity space (method B). This clearly suggests that both of the methods introduce a bias that can be interpreted as a real correlation.

Nevertheless, by using Monte-Carlo simulations, we found that the number of pairs that forms with method B and at velocity separations lower than 100 km s^{-1} is significantly larger (at 3σ) than if galaxies where randomly distributed in velocity space, which indicates that a correlation indeed exists in our sample between O VI absorbers and galaxies. The next step will be to include other characteristics to form the pair, such as the type, colour, or magnitude of the galaxies.

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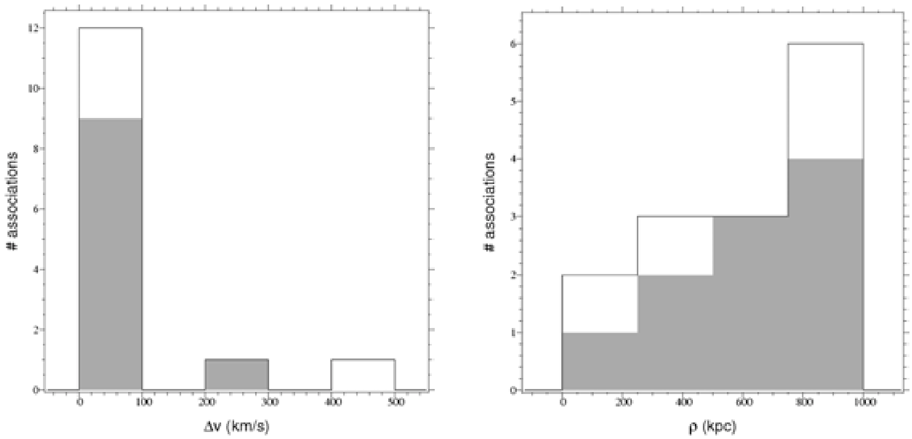

Figure 2. Same as Fig. 1, but the associations are made with the near-neighbour method.

Also, the right panel of Fig. 1 shows that some absorbers cannot be associated with a galaxy that is at less than 250 kpc. These isolated absorbers need further investigation to understand how they arrive or form so far from any visible galaxies.

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