# LARGE SCALE STRUCTURE IN THE LY$\alpha$ FOREST

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## 1. Introduction

We have conducted a survey of the Ly$\alpha$ forest in the redshift domain $2.15 < z < 3.37$ in front of nine QSOs within a 1° field to probe spatial structure along planes perpendicular to the line-of-sight. We find evidence for correlations of the Ly$\alpha$ absorption line wavelengths in the whole redshift range, and, at $z > 2.8$, of their equivalent widths. Such a correlation is consistent with the emerging picture that Ly$\alpha$ lines arise in filaments or large, flattened structures.

## 2. Data

We have examined the Ly$\alpha$ forest in front of 9 QSOs in a $\sim 1°$ field. The 2 Å resolution spectra were obtained in the course of a parallel C IV absorber study (Williger *et al.* 1996). We exclude Ly$\alpha$ forest lines within 5000 km s$^{-1}$ from the background QSO to avoid problems with the "proximity effect," as were all Ly$\alpha$ lines corresponding to known metal systems from the C IV survey (Willinger *et al.* 1996). 299 Ly$\alpha$ lines with $W_0 \geq 0.3$ Å were detected at $\geq 5\sigma$ confidence level at redshifts $2.15 < z < 3.37$, with 377 lines at a lower (incomplete) detection threshold of $W_0 = 0.1$ Å. We checked that the individual lines-of-sight do not present peculiarities that could undermine our analysis. Indeed, we find no significant variations in the number of Ly$\alpha$ absorbers from a power law distribution in redshift, and no anomalously large voids (Ostriker *et al.* 1988).



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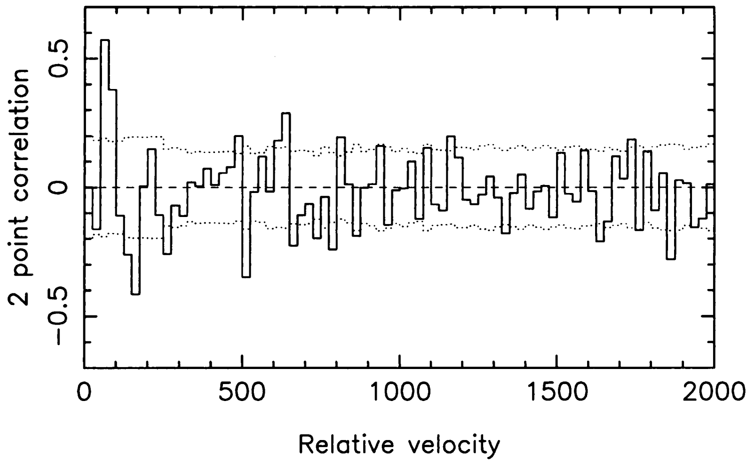


*Figure 1.* The Ly$\alpha$ forest two point correlation function at $2.6 < z < 3.3$ with rest equivalent width $W_0 \geq 0.1$ Å. Dotted lines show $1\sigma$ scatter from 1000 synthetic datasets. The chance probability of a feature arising anywhere at least as significant at $50 < \Delta v < 100$ km s$^{-1}$ is $P = 0.0001$

## 3. Analysis

Various statistical methods (two-point correlation function, nearest neighbour test, distribution of line separations in velocity space) were then applied to probe for structure in velocity space, ignoring the angular separation between the quasars. This tests for structures in the plane of the sky at various redshifts. Sets of 1000 synthetic datasets using data-shuffling techniques were used to estimate the significance of features in the distribution functions. We find an excess of Ly$\alpha$ absorbers with separations

$50 < \Delta v < 100$ km s$^{-1}$, especially strong over $2.60 < z < 3.25$ (Figure 1). We find no significant difference in the correlations as a function of angular separation. The correlations must come from different lines of sight as the minimum separation between absorbers along any one line of sight is $\Delta v \sim 300$ km s$^{-1}$. We have examined the difference in rest equivalent width for all line pairs with $50 < \Delta v < 100$ km s$^{-1}$, where the overabundance is found in the two point correlation function. For the 183 lines with $W_0 \geq 0.1$ Å and $2.80 < z < 3.25$, we find that the pairs of lines with rest equivalent width differences $\Delta W_0 \leq 0.2$ Å are overabundant (Figure 2). This is not simply from an overall normalisation difference; rather, the line pair excess is concentrated toward small values. The correlation appears to be independent of $W_0$ and angular separation. We have re-analysed data on a smaller angular scale from the literature (*i.e.*, Cotts 1989) as above, using all lines with significance $> 4\sigma$, and find similar effects.

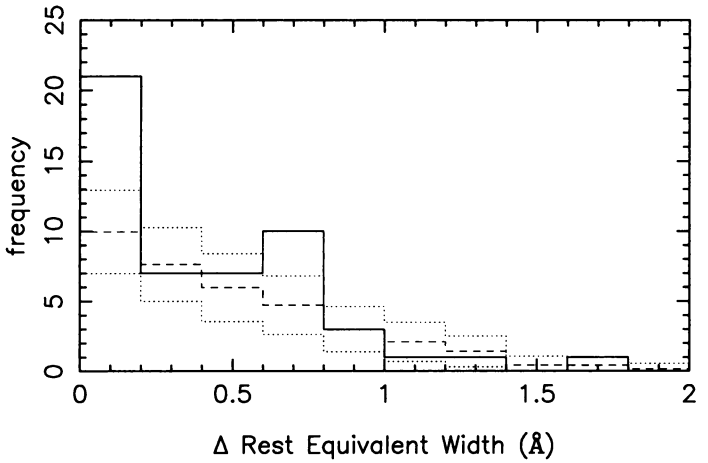


*Figure 2.* The equivalent width difference distribution at $2.8 < z < 3.25$, $W_0 \geq 0.1$ Å and $50 < \Delta v < 100$ km s$^{-1}$. The solid line denotes data, the dashed line the mean from 1000 synthetic datasets and the dotted line the $1\sigma$*scatter*. The chance probability of a feature at $0 < \Delta W_0 < 0.2$ Å at least as significant as observed is $P < 0.001$.

## References

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