Evidence of Structure in the Lyman-α Forest

Jochen Liske and John K. Webb

Department of Astrophysics & Optics, University of New South Wales, Sydney 2052, Australia

Abstract. The spatial distribution of Ly-α forest absorption systems toward a group of eight closely spaced QSOs has been analysed and evidence for large scale structure has been found at $\langle z \rangle = 2.8$. Our technique is based on the first and second moments of the transmission probability density function which is capable of identifying and assessing the significance of regions of over- or underdense Ly-α absorption. The data has revealed at least two interesting features. 1. An overdense structure at $z = 2.27$ which extends at least over $\sim 8\, h^{-1}$ comoving Mpc ($q_0 = 0.5$) in the plane of the sky. Metal absorption lines have been found at the same redshift and thus a cluster or proto-cluster of galaxies seems to have been discovered. 2. A void at $z = 2.97$, extending over $\sim 20\, h^{-1}$ comoving Mpc in the plane of the sky, possibly caused by a locally increased UV ionising flux due to a foreground QSO.

1 Introduction

Recent work (Lanzetta et al. 1995) has shown that at least some fraction of the Ly-α absorption lines seen in the spectra of low redshift QSOs arises in the extended haloes of galaxies. At high redshift, Ly-α absorbers are found to be strongly clustered (Fernández-Soto et al. 1996) and many contain ionised carbon (Cowie et al. 1995). This suggests that some fraction of high redshift Ly-α absorbers may also be identified with the haloes of galaxies. Thus it seems likely that the Ly-α forest may exhibit large scale structure.

However, it has been shown (Fernández-Soto et al. 1996) that significant clustering may be missed when using the classical tool of cluster analysis, the two-point correlation function (Peebles 1993, Sargent et al. 1980). Here, we present a new technique to search for non-randomness in the spatial distribution of the Ly-α forest based on the first and second moments of the transmission probability density function. This method is able to identify the strength, position and scale of individual structures since it retains spatial information. It is fairly insensitive to noise and resolution characteristics and is easy to apply in practice. The new technique has been tested with the help of synthetic spectra and it was found to be substantially more sensitive than a two-point correlation function analysis.

2 Results

The method was applied to the spectra of a close group of eight QSOs with a mean redshift of 2.97. The data (Williger et al. 1996) was kindly made available to us by Gerry Williger.

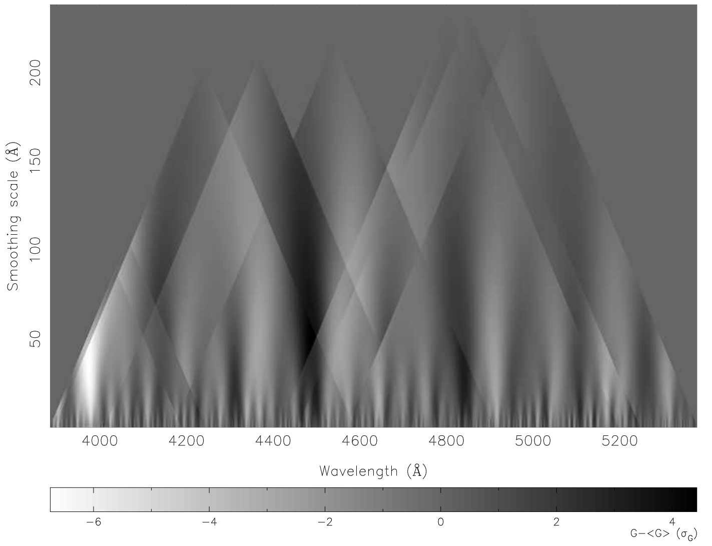

Fig. 1. Transmission in the spectra of a group of eight closely spaced QSOs as a function of wavelength and smoothing scale. The transmission is measured relative to a theoretical expectation value and in units of the theoretical standard deviation by convolving the spectra with a Gaussian of varying size. Each "triangle" corresponds to one spectrum, where the base is the original spectrum itself and the tip is a value comparable to $1-D_A$, D_A being the flux deficit parameter (Oke and Korycansky 1982).

Figure 1 shows the result of the analysis. The most prominent feature is a 6.7σ overdensity of absorption at 3976 Å ($z = 2.271$). It is due to the spectra of Q0041-2707 and Q0041-2658. The two lines of sight are separated by 2.4 h^{-1} proper Mpc ($q_0 = 0.5$) and the feature covers $\sim$ 2700 km s^{-1} in velocity space. Williger et al. (1996) find metal absorption at redshift 2.2722 in the spectrum of Q0041-2658, which is remarkably consistent with the redshift of the overdense structure.

There are also two noticeable voids at $\sim$ 4490 Å and at 4842 Å. The second void is possibly due to a foreground QSO which lies within 500 km s^{-1} of the underdensity.

References

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