THE CORRELATION OF THE LYMAN- α FOREST AND METALS IN CLOSE PAIRS OF HIGHT-REDSHIFT QUASARS

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We derive the transverse flux correlation function in the Lyman- α forest at $z \sim 2.1$ from Abstract. VLT-FORS observations of a total of 32 pairs of quasars. The shape and correlation length of the transverse correlation function are in good agreement with the paradigm of intergalactic medium predicted in CDM-like models for structures formation. Using a sample of 139 C IV systems detected along the lines of sight toward the pairs of quasars we investigate the transverse correlation of metals on the same scales. We find that the correlation function is consistent with that of a randomly distributed population of C IV systems. However, we detect an important overdensity of systems in front of a quartet.

Introduction 1

The intergalactic medium (IGM) is revealed by the numerous H I absorption lines seen in the spectra of distant quasars, the so-called Lyman- α forest. There is a long history of using the flux transverse correlation in the Lyman- α forests of QSO pairs to measure the spatial extent of the corresponding absorbing structures. The Lyman- α forests in the spectra of multiple images of lensed quasars or pairs of quasars with separations of the order of a few arcsec (Smette et al. 1995; Impey et al. 1996) appear nearly identical implying that the absorbing structures have sizes $>50h_{75}^{-1}$ kpc. Significant correlation between absorption spectra of adjacent lines of sight toward quasars still exists for separations of a few to ten arcmin suggesting dimensions or better a coherence length of the structures larger than 500 h_{75}^{-1} kpc (e.g. Petitjean et al. 1998; Aracil et al. 2002).

$\mathbf{2}$ The transverse and longitudinal flux correlation functions

We derive the transverse and longitudinal flux correlation functions from 32 QSO pairs. We use N-body simulations to understand the effect of thermal broadening and peculiar velocities, evaluate uncertainties and interprete the observations. The comparison between the observed and predicted transverse and longitudinal correlation functions is a valuable test of the theory of the Intergalactic Medium. In addition, by fitting the two correlation functions it may be possible, as a final goal, to constrain the cosmological geometry through the Alcock & Paczyński (1979) test as proposed by McDonald & Miralda-Escudé (1999) and Hui et al. (1999) (see also Rollinde et al. 2003). This goal will be achieved only with a major observational effort. Indeed, it has been shown that this should require a number of pairs as large as $13(\theta/1)^2$ on scales at least up to 10 arcmin (McDonald 2003). It is therefore crucial as a first step and before embarquing in a large survey to demonstrate that the general theoretical scheme is consistent with observations.

Each quasar pair yields one data point of the transverse correlation function. The observed transverse correlation coefficients measured from the 32 pairs are shown in Fig. 1. We have gathered the observed measurements in bins weighting the points by the errors. Overplotted as a continuous line is the correlation function measured in the hydrodynamic simulation at z = 2.

Predictions from linear theory are compared for different values of Ω_m . Despite the larger sample than in Rollinde et al. (2003), we cannot distinguish between different values of $\Omega_{\rm m}$. However, our result demonstrates the presence of a strong signal in the transverse correlation on scales < 5 arcmin and justifies the investment in observing time that will be needed to extract the information on Ω_{Λ} .

It can be seen that the shape of the observed function is consistent with what is expected both from the simulations and the linear theory. Besides, if one assumes the favored LCDM cosmology, with $\Omega_{\rm m} = 0.3$, a non linear signal is probably present in the transverse direction for $\theta < 1$ arcmin, as expected from the fully non-linear hydrodynamic results. This demonstrates that data are consistent with the current scheme describing the Lyman- α forest as the tracer of a continuous photoionized and warm intergalactic medium as associated with the filamentary and sheet-like structures predicted in cold dark matter-like models for structure formation.



Figure 1: The observed transverse correlation coefficients for individual pairs (black dots) and binned (histogram) are overplotted over the transverse correlation function from the hydro-simulation and linear predictions for $\Omega_{\rm m} = 0.1, 0.3$ and 1 (thin solid, dashed and dotted lines respectively)

3 C IV systems

To estimate the correlation of intervening C IV systems in the QSO pairs, we apply the Nearest-Neighbor method, as described in Young et al. (2001) and Aracil et al. (2002) to a list of selected C IV systems. For each absorption line along one QSO line of sight, we search the adjacent QSO line of sight for the nearest (in velocity) absorption line.

There is a possible small excess of clustering of C IV systems on scale smaller than 5000 km s⁻¹. This scale is larger than the typical correlation length, about 1000 km s⁻¹, seen in the longitudinal correlation function of C IV systems (Rauch et al. 1996, Pichon et al. 2003, Scannapieco et al. 2005). This is due to an excess of associations in the bin $\Delta V \sim 4000$ km s⁻¹. Looking in more details at the lines of sight from which this excess comes from shows that most of the corresponding C IV associations are located in the peculiar field of the quartet Q 0103-295A&B, Q 0102-2931 and Q 0102-293, we find 9 out of the 25 C IV with $\Delta V < 5000$ km s⁻¹.

4 Conclusion

The shape and correlation length of the observed transverse correlation function are in good agreement with those expected from absorption by the filamentary and sheet-like structures in the photoionized warm intergalactic medium predicted in CDM-like models for structures formation. However, it is apparent from Fig. 1 that although the sample is unique, it is not sufficient to significantly constrain the geometry of the universe. This confirms the predictions by McDonald (2003) that significant constraints can be obtained on Ω_{Λ} only with a large number of pairs of the order of $13(\theta/1')^2$ on scales at least up to 10 arcmin. Our result demontrates the presence of a strong signal in the transverse correlation on scales < 5 arcmin and justifies the investment in observing time that will be needed to extract the information on Ω_{Λ} .

No correlation signal is seen in metal lines (C IV) on the scales probed by our pairs. This is not surprising as most of the separations are larger than 2 comoving Mpc derived by Scannapieco et al. (2005) for metal-enriched bubbles surronding massive haloes. Finally, we detect an important overdensity of systems in front of the quartet Q 0103–295A&B, Q 0102–2931 and Q 0102–293 extended over the redshift range $1.7 \le z \le 2.2$ and on a spatial scale larger than 10 arcmin.

References

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