The Two-Point Correlation Function of Randomly Distributed Lyman-α clouds

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It is often assumed that Lyα forest clouds are randomly distributed, intergalactic objects that are highly ionized by the UV background produced by quasars. If these assumptions are true, fluctuations in the UV background should produce a nonzero two-point correlation function in the Lyα forest. This effect, which is really just a generalization of the proximity effect (Bajtlik et al. 1988), is more significant at high redshift ($z \approx 3 - 4$) because the mean free path for UV photons is smaller there, and the fluctuations correspondingly larger. We have studied this effect using both the semi-analytic techniques of Zuo's recent papers (1992a,b) and Monte Carlo simulations. The correlation function is expected to have a small yet potentially measurable amplitude that is consistent with current upper limits. Furthermore, the signature of this effect is distinctive because the nonzero correlation function extends over the photon mean free path, which is larger than the expected scale of large-scale structure. Observations or upper limits on this effect could provide information about the source of the ionizing background at high redshifts and the nature of the Lyα forest clouds.

The basic idea is the same as in the proximity effect. The neutral column density for a highly photoionized system is inversely proportional to the flux J_L at the Lyman limit, or more precisely to the photoionization rate; the distinction is important and is treated in a simplified manner. The distribution of H I column density N is proportional to $N^{-\beta}$, with $\beta \approx 1.7$. The observed density of Lyα clouds, which is assumed to be determined by a lower column density limit, is proportional to $J_L^{1-\beta}$. Then the two-point correlation function is

$$\xi(r) = \frac{\langle J_{L1}^{1-\beta} J_{L2}^{1-\beta} \rangle_r}{(\langle J_L^{1-\beta} \rangle)^2} - 1.$$

The average in the denominator is taken over all points in space, and the numerator is averaged over all pairs of points that are separated by a distance r. $\xi(r)$ depends on the point-source density, luminosity function, and distribution of the absorbers. The expected correlation function for redshift $z = 4.0$ is shown in Figure 1. The correlation function extrapolated to zero separation is shown as a function of redshift in Figure 2.

References

Bajtlik, S., Duncan, R. C., and Ostriker, J. P., 1988. Ap. J., **327**, 570.

Møller, P., and Warren, S., in *The Space Distribution of Quasars*, ed. D. Crampton (Astronomical Society of the Pacific).

Zuo., L., 1992a. M. N. R. A. S., submitted.

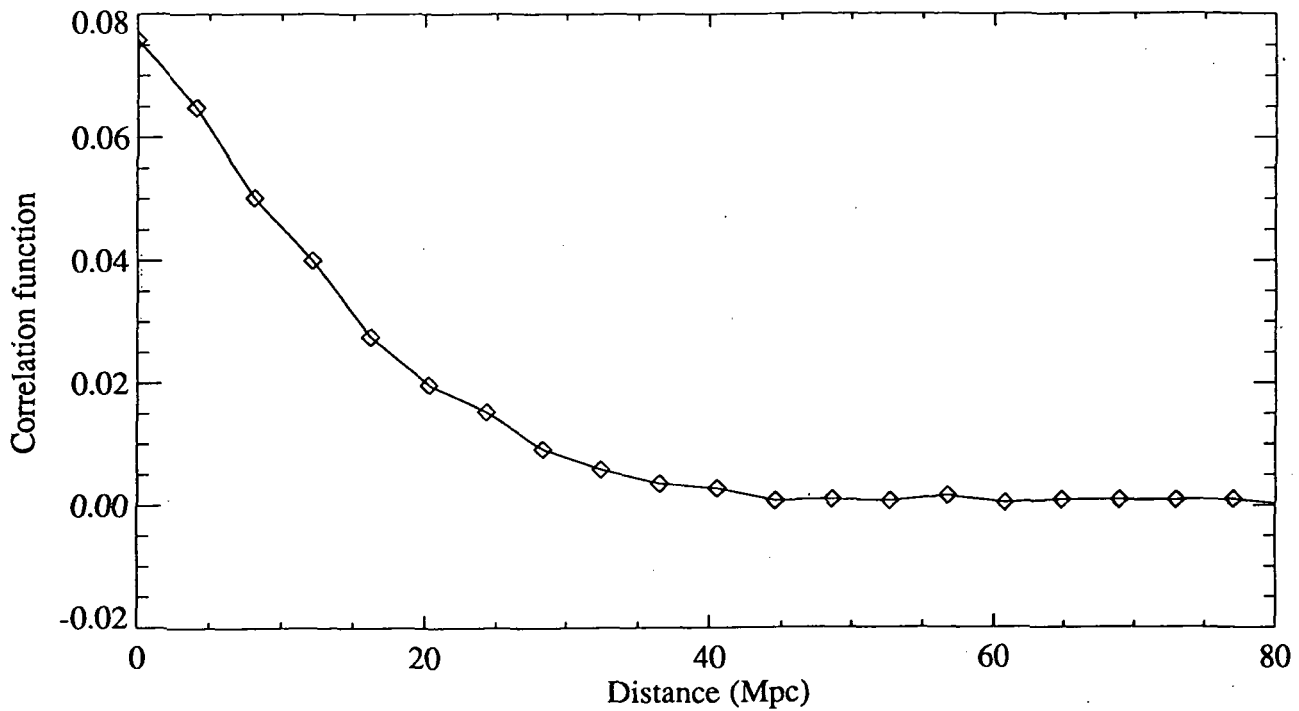Zuo., L., 1992b. M. N. R. A. S., submitted.

Figure 1. Expected correlation function at redshift $z = 4.0$, assuming exponential attenuation, UV power-law slope $p = -1$, constant comoving space density of quasars, and Møller and Jakobsen's (1991) model for the absorbers. Produced with truncated Monte Carlo technique. The absorption length here is 21.2 Mpc.
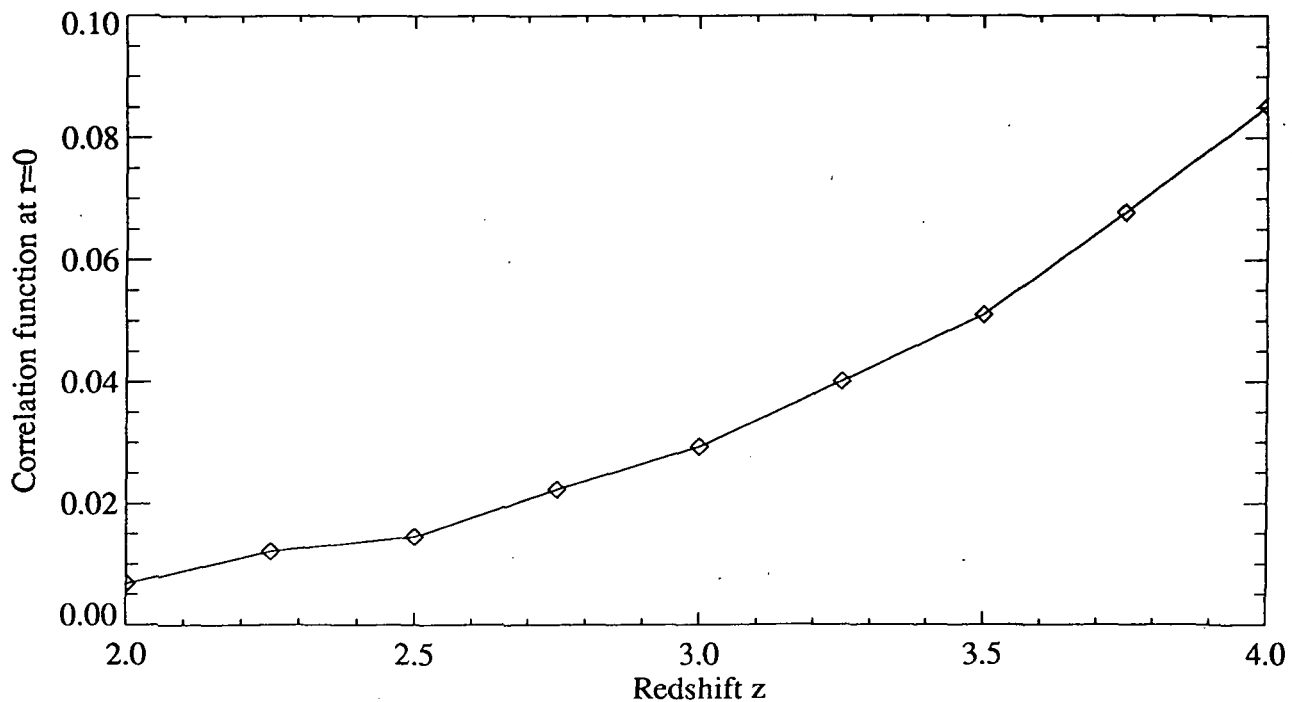

Figure 2. Maximum correlation function (correlation function extrapolated to zero separation) as a function of redshift; same assumptions as above but FT method used.