CLUSTERING PROPERTIES OF LYα ABSORPTION LINES IN NUMERICAL SIMULATIONS

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Recently a number of results from numerical simulations has been published by serveral authors describing the column density and line number density distribution of the Lymanα forest extremely well. Our goal is now to analyse the clustering properties of the Lymanα lines from numerical simulations and compare them to the observed ones. We show that defining two different populations of Lymanα absorber clouds and calculating the two-point correlation function of the lines from each population independently makes it possible to distinguish between a clustered and a Poisson distributed component.

To study the clustering of the Lymanα line absorbers, a PM simulation with dark matter and baryonic gas component (including thermal evolution) in a box of 12 Mpc and a resolution of 50 kpc has been done. This simulation is described in Mücket et al.[2] and Riediger et al.[3] in detail. We constructed lines of sight for a redshift range up to $z = 5$. Special precaution have been taken to avoid influences of the periodic boundary conditions. From those lines of sight, two-point correlation functions are calculated for different redshift ranges and column density cuts as done for observational data in Cristiani et al.[1].

We distinguish between two populations of Lymanα absorber clouds in the simulation: clouds for which shock-heating has been important at some time of their thermal history (P_s), and clouds for which photo-ionization is the dominant heating process all the time (P_u). Population P_s is mostly found in big halos and elongated filaments, population P_u is present in the surroundings of structures formed by shocked particles but mostly in the voids delineated by those structures.

Two-point correlation functions have been calculated for the Lymanα absorption lines of one or both populations. It can be seen in Fig. 1 (left column top) that the signal of the correlation function for all lines of both populations $P_s + P_u$ and a column density cut of $\log N_{\rm HI} > 13$ (which is equal to the sample examined by Cristiani et al.[1]) is rather low. However, if increasing the column density threshold to $\log N_{\rm HI} > 14$, the signal also increases significantly (left column bottom; cf. Fig. 1 and 2 of Cristiani et al.[1]). This suggests that the low column density clouds are only weakly clustered (left column middle) and depress the overall signal. However, examining the correlation function of the filamentary population P_s only (right column) shows that this population seems to be strongly clustered. The signal is already present in the full sample (right column top) and a shift of the column density cut to $\log N_{\rm HI} > 14$ (right column bottom) does not change the signal significantly. Also, the thus ignored clouds $14 > \log N_{\rm HI} > 13$ seem to be correlated in the same way (right column middle).

The general trend in the correlation function for different redshifts at $\log N_{\rm HI} > 14$ which seems to be present for both populations $P_{\rm s} + P_{\rm u}$ (Fig. 2, left column; same behavior as been found in the obseravtional data of Cristiani et al.[1], see their Fig. 4) behaves different when examining the filamentary population $P_{\rm s}$ only (right column). For both populations the signal of the correlation function is increasing with descreasing redshift due to the delution of the void population clouds (left column, bottom upwards). At low redshift, the filamentary population becomes dominant. The signal of the correlation function of the pure filamentary population remains nearly at equal level (right column). The stronger signal for medium redshift might result from two contrary evolving effects: at low decreasing redshift, the clouds of the filamentary population flow along the filaments to form clusters which result in a weaker signal in the one-dimensional correlation function. On the other hand, at high redshift, the large scale structure of the universe is not yet very developed so the signal is weak, too.

Another reason for a decreasing signal at low redshift might be the limitation of the numerical resolution: the simulation has been done for a comoving boxsize of 12 Mpc, so only one significant structure will be present in the simulated box at $z \approx 0$. Further simulations with larger box sizes will be done to investigate the behavior of the correlation function more reliably.

References

1. S. Cristiani, S. D'Odorico, V. D'Odorico, A. Fontana, E. Giallongo, S. Savaglio; *MNRAS* **285**, 209 (1997)
2. J.P. Mücket, P. Petitjean, R.E. Kates, R. Riediger; *A&A* **308**, 17 (1996)
3. R. Riediger, P. Petitjean, J.P. Mücket; *A&A* (1997), in press

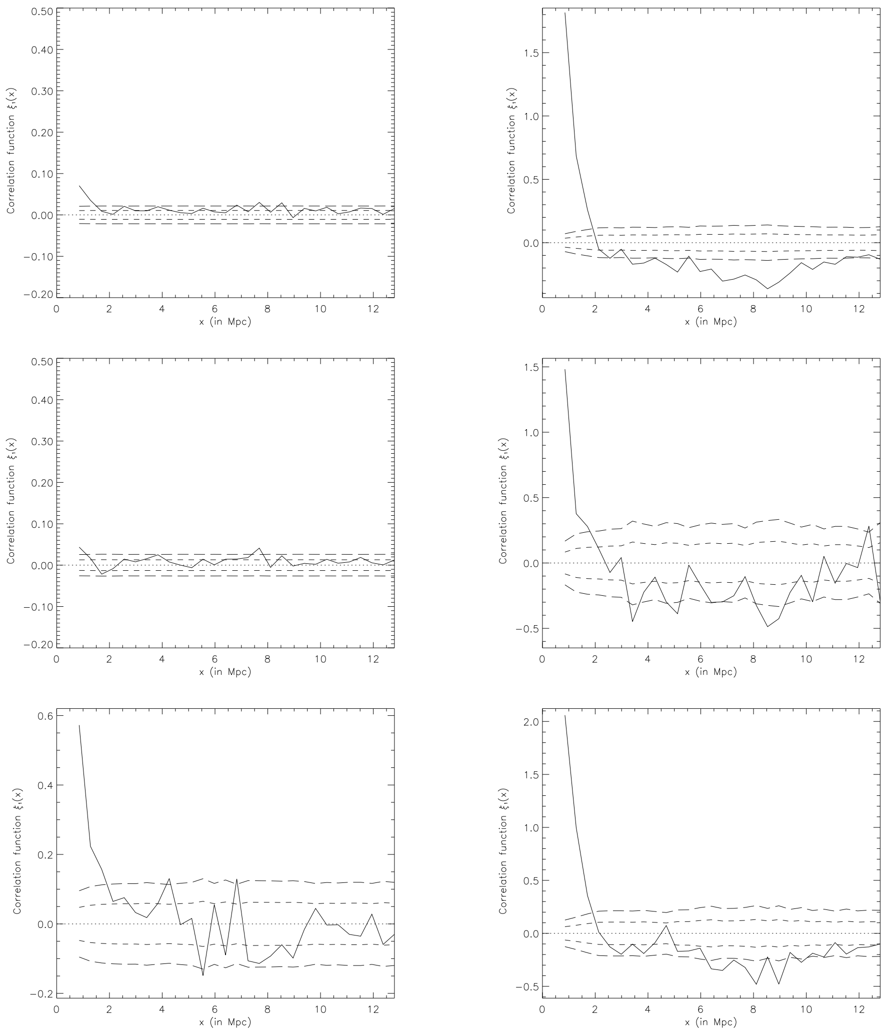

Figure 1: Comparison of different column density cuts at redshift $3.1 < z < 3.5$ for $\log N_{\mathrm{HI}} > 13$ (top), $14 > \log N_{\mathrm{HI}} > 13$ (middle), and $\log N_{\mathrm{HI}} > 14$ (bottom) respectivly, given for both populations $P_{\mathrm{s}} + P_{\mathrm{u}}$ (left) and the filamentary population P_{s} only (right). The short dashed lines gives the 1σ, the long dashed the 2σ confidence level.

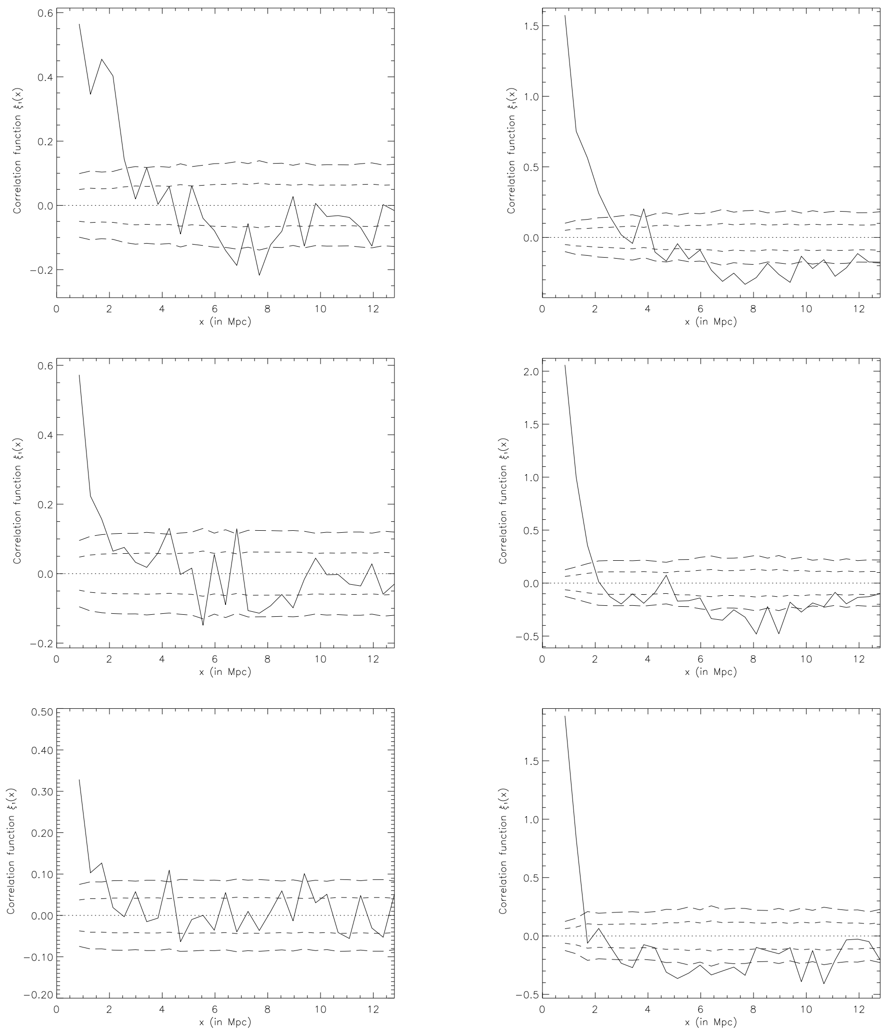

Figure 2: Comparison of different redshift at same column density cut $\log N_{\rm HI} > 14$ for $1.7 < z < 3.1$ (top), $3.1 < z < 3.5$ (middle), and $3.7 < z < 4.0$ (bottom) respectivly, given for both populations $P_{\rm s} + P_{\rm u}$ (left) and the filamentary population $P_{\rm s}$ only (right). The short dashed lines gives the 1σ, the long dashed the 2σ confidence level.