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Probing the small scale structure of the Inter-Galactic Medium with ESPRESSO: spectroscopy of the lensed QSO UM673 ⋆

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ABSTRACT

The gravitationally lensed quasar J014516.6-094517 at $z = 2.719$ has been observed with the ESPRESSO instrument at the ESO VLT to obtain high-fidelity spectra of the two images A and B with a resolving power $R = 70000$. The Lyman forests, separated by sub-kiloparsec physical distances at the redshifts under investigation ($2.1 \lesssim z \lesssim 2.7$), exhibit a notable degree of correlation between the two sightlines. With the present level of signal-to-noise ratio and accuracy they are indistinguishable and globally do not show any drift, with the cross-correlation peaking at $\Delta v = 27 \pm 59$ m s^{-1}. The distribution of the difference in velocity of individual Lyman-α features is compatible with a null average and a mean absolute deviation of 930 m s^{-1}. Significant differences in $N_{\rm HI}$ column density are not detected, putting a limit to the RMS fluctuation in the baryon density on $\lesssim 1$ proper kpc scales of $\Delta\rho/\rho \lesssim 3\%$. On the other hand, metal lines show significant differences both in velocity structure and in column density. A toy model shows that the difference in velocity of the metal features between the two sightlines is compatible with the the motions of the baryonic component associated to dark matter halos of typical mass $M \simeq 2 \times 10^{10} M_{\odot}$, also compatible with the observed incidence of the metal systems. The present observations confirm the feasibility of the Sandage test of the cosmic redshift drift with high-fidelity spectroscopy of the Lyman Forest of distant, bright quasars, but also provide an element of caution about the intrinsic noise associated to the usage of metal features for the same purpose.

Key words: intergalactic medium – quasars: absorption lines – cosmology: observations

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