The Hardening of the UV Background near Quasars

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We report on the detection of a systematically harder intergalactic UV radiation field in the vicinity of QSOs at $2.2<z<3.2$. By comparing the intergalactic He II absorption to the corresponding H I absorption, we recovered the fluctuating spectral shape of the UV background towards Q 0302–003 (z=3.285) and HE 2347–4342 (z=2.885). We correlated the spectral shape variations with foreground QSOs discovered in a dedicated survey near the these two lines of sight. We find a hard radiation field near the background QSOs and in the vicinity of the seven known foreground QSOs (four near Q 0302–003 and three in the vicinity of HE 2347–4342). We interpret this as the proximity effect in spectral hardness acting on distances of several Mpc. The spectral hardness breaks the density degeneracy due to cosmic variance that is responsible for the non-detections of the transverse proximity effect as a void in the H I forest.

The Transverse Proximity Effect

In the vicinity of QSOs the intergalactic medium is statistically more highly ionized due to the local enhancement of the UV flux that results in a statistically higher H I transmission ('void'). While this so-called proximity effect has been found on lines of sight towards QSOs (e.g. Bajtlik et al. 1988; Scott et al. 2000), a transverse proximity effect created by foreground QSOs nearby the line of sight has not been clearly detected in the H I forest (e.g. Schirber et al. 2004, Croft 2004).

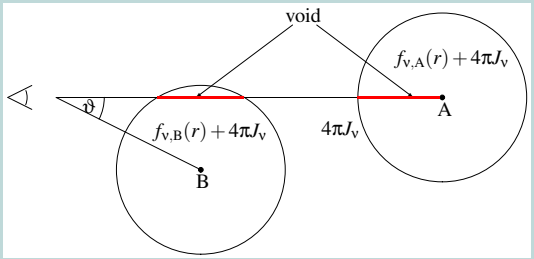


Illustration of the proximity effect. QSO A and foreground QSO B locally enhance the UV background J_ν and create an underdensity in the Lyα forest with respect to the average absorption at that redshift.

Intergalactic He II Absorption

On clear lines of sight far-UV spectroscopy with HST and FUSE revealed the intergalactic He II Lyα absorption (e.g. Heap et al. 2000, Kriss et al. 2001, Fechner et al. 2006). Although the transverse proximity effect has been found as a void in the He II Gunn-Peterson trough near a foreground quasar towards Q 0302–003 (Jakobsen et al. 2003), we do not detect additional underdensities towards Q 0302–003 and HE 2347–4342 near our foreground QSOs.

The Transverse Proximity Effect in Spectral Hardness

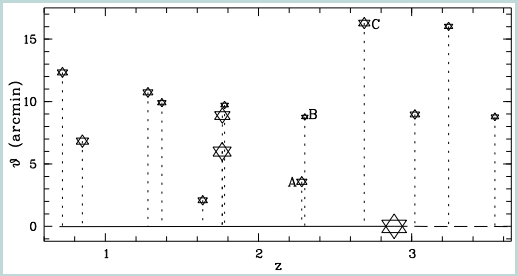
Due to the different ionization potentials of H I and He II the column density ratio $\eta=N_{\rm HeII}/N_{\rm HI}$ indicates the spectral shape of the UV radiation field. By comparing the H I and the He II absorption we are able to distinguish hard quasar radiation ($\eta \lesssim 100$) from soft radiation by star-forming galaxies ($\eta \gtrsim 100$) along the line of sight.

Though the He II forest towards Q 0302–003 remains unresolved at the low STIS resolution, we inferred η by comparing the data with simulated He II absorption generated from the H I line list as a function of η. The FUSE spectrum of HE 2347–4342 resolves the He II forest and η was directly estimated by line fitting.

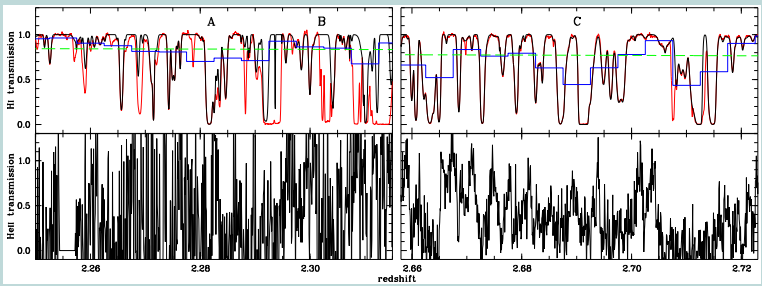
We find that the radiation field is systematically harder than on average near all seven foreground QSOs on both lines of sight. This hardening is also visible near the central QSOs. Due to the hard spectral energy distribution of QSOs we interpret this as a signature of the transverse proximity effect in the fluctuating UV spectral shape. In addition, at least two out of three analyzed metal line systems towards HE 2347–4342 located near the foreground QSOs are consistent with a local QSO contribution to the ionizing field based on the unambiguous detection of O VI at z=2.712 and N V at z=2.275.

The Survey "Quasars near Quasars"

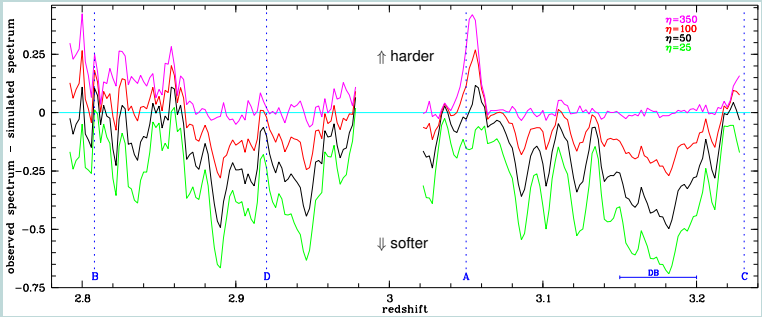
We performed a slitless spectroscopic survey for faint QSOs around 16 luminous high-redshift QSOs with the ESO Wide Field Imager. 80 candidates were confirmed. Together with known QSOs from the literature, four QSOs near Q 0302–003 and three QSOs near HE 2347–4342 can be used to study the transverse proximity effect.



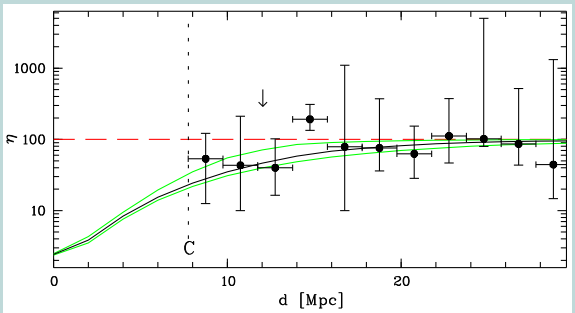
Angular distance ϑ vs. redshift z of the 14 QSOs around HE 2347–4342 with respect to HE 2347–4342. We study the transverse proximity effect of the three foreground QSOs A, B and C (z_A=2.282, z_B=2.302, z_C=2.690).



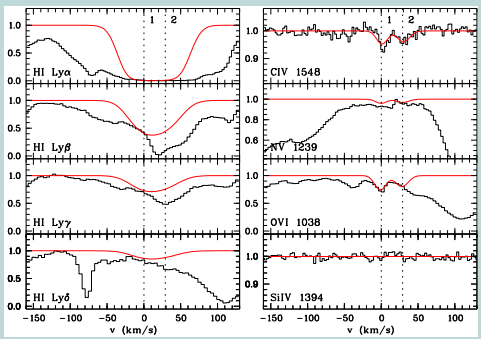
The Lyα forest of HE 2347–4342 in the vicinity of three foreground QSOs A, B and C. The upper panels show the observed optical spectrum (red), the H I transmission (black), the mean transmission towards HE 2347–4342 (binned line) and expected mean transmission (dashed line). The lower panels display the corresponding He II transmission.



Observed vs. predicted He II Lyα absorption towards Q 0302–003 in differential representation (observed minus predicted) for different η values. Positive (negative) deviations from zero indicate that η has to be smaller (higher) than the assumed η of the curve, corresponding to harder (softer) radiation. The radiation field near the foreground QSOs A–D is harder ($25\lesssim\eta\lesssim100$) than far away from them ($\eta\sim350$).



Column density ratio η in bins of Δd=2 Mpc vs. proper distance d between QSO C and HE 2347–4342 (filled circles). The minimum separation between the two QSOs is 7.75 Mpc in the cosmological concordance model. Hard radiation corresponds to small η. The black line shows the modelled decrease of η approaching QSO C with respect to the ambient soft UV background with $\eta\sim100$ (dashed line). Near the quasar the radiation field is harder than on average despite large small-scale fluctuations. The arrow marks the metal line system at z=2.7119.



Metal line system at z=2.7119 towards HE 2347–4342. The binned lines represent the observed data. The fitted Doppler profiles (red) are used to constrain the shape of the UV radiation field.

Conclusions

The spectral hardness breaks the density degeneracy due to cosmic variance that is responsible for the frequent non-detections of the transverse proximity effect. It is a sensitive physical measure to reveal the transverse proximity effect even in intrinsically overdense regions or in cases where the local quasar radiation only marginally exceeds the UV background. From the transverse proximity effect of the foreground QSOs we infer QSO lifetimes of 10–30 Myr.

Publications

Worseck & Wisotzki 2006, A&A, 450, 495
Worseck et al. 2007, submitted to A&A, arXiv:0704.0187