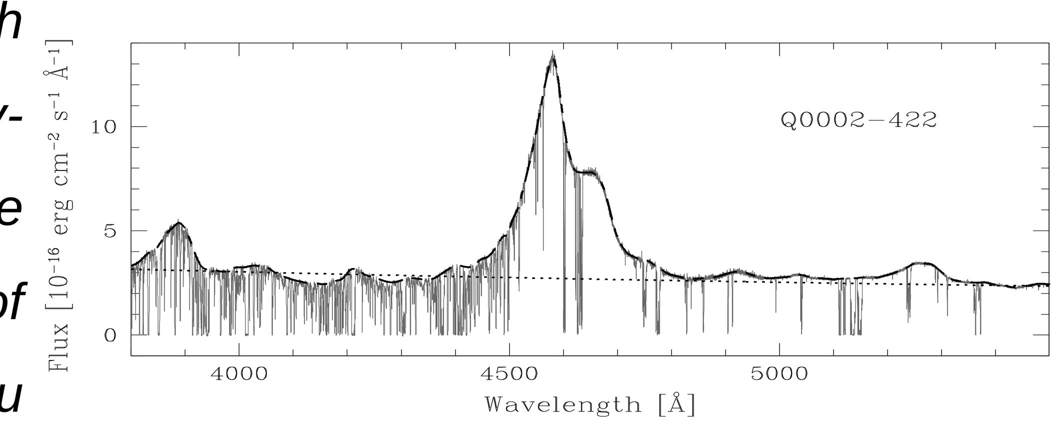
An unbiased measurement of the UV background and its evolution via the proximity effect statistic

Aldo Dall'Aglio, Gabor Worseck and Lutz Wisotzki
Astrophysikalisches Institut Potsdam

AIP

We have used a sample of 40 high resolution (R ~ 45000), high signal-to-noise (S/N ~ 70) quasar spectra to search for the signature of the so-called proximity effect in the HI Lyα forest at 2.1 < z < 4.7. We analyse the spectra employing the flux transmission statistic detecting the proximity effect towards each QSO at high significance. We investigate the distribution of the proximity effect strength and develop a new technique yielding very accurate measurements of the UV background intensity. We infer log J(ν₀) = -21.51 ± 0.15 which agrees with the prediction by Haardt & Madau (2001). This method allows us to investigate the influence of cosmic variance, quasar properties and gravitational clustering on the strength of the proximity effect. We estimate that about 25% of our objects are flagged as hosted by a strongly clustered environment. Removing them, we evaluate the redshift evolution of the UV background intensity over the range 2 < z < 4. Our results indicate a significant decline in the background intensity towards high redshift, consistent with a scenario of the UV background generated by both quasars and star-forming galaxies.*



The proximity effect towards individual QSOs

In the vicinity of UV sources (such as luminous QSOs) the UV flux exceeds the UV background (UVB), thereby reducing the density of intergalactic neutral H. This effect creates a statistically higher transmission close to the quasar than far away from it. This is the so-called proximity effect. We systematically searched for the proximity effect towards all 40 quasars in our sample finding a significant departure from unity in the normalised effective optical depth approaching each quasar.

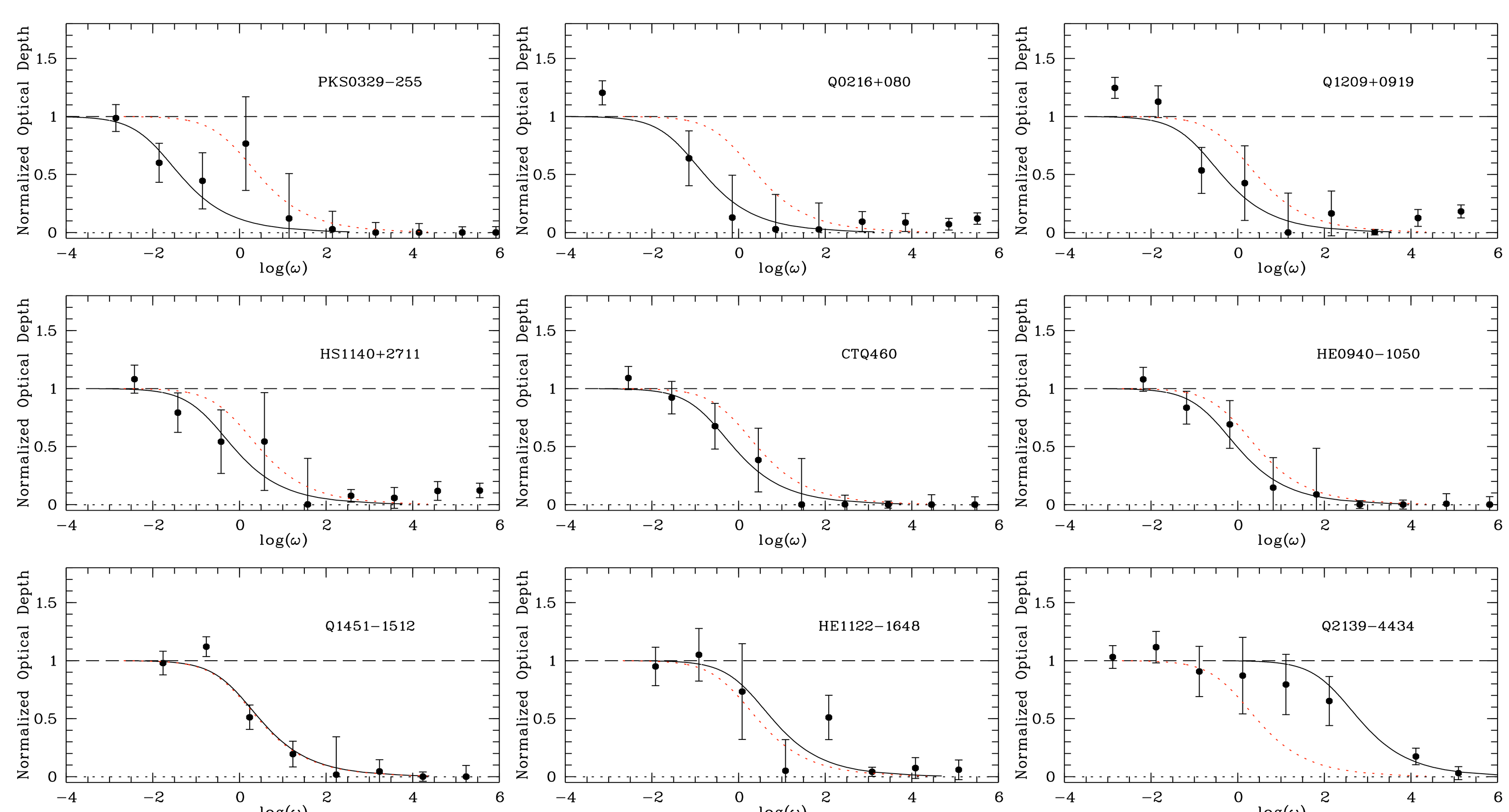


Fig 1.: The proximity effect signatures in individual lines of sight, for a subset of 9 QSOs. Each panel shows the normalised effective optical depth ξ versus ω binned in steps of Δlog(ω) = 1 (with ω being the ratio of the quasar and background photoionization rates). The dotted lines display the reference UVB assumed to be log J(ν_0) = -21. The solid lines delineate the best fit to each individual QSO. The panels are sorted in order of decreasing strength of the proximity effect (horizontal displacement of solid and dotted lines).

The proximity effect strength distribution

The least-square fit of the Bajtlik et al. (1988) model to the data returned the parameter *a*, which describes the horizontal offset between the actual fit (solid line) and the assumed curve for the reference UVB (dotted line), as seen in the left-hand panels of Fig.2. We treat this values as a measure of the strength of the proximity effect signal.

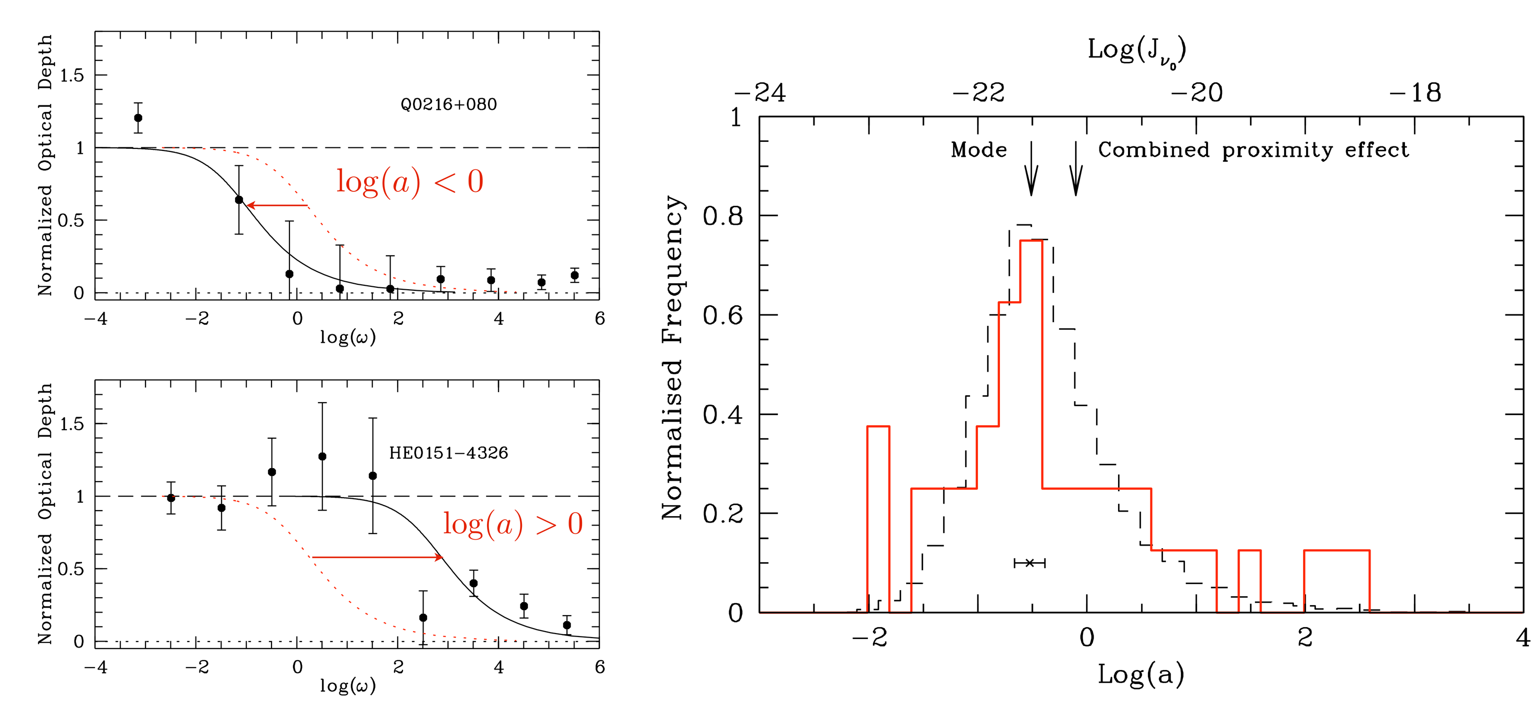


Fig 2. Right-hand panel: Comparison between observed (solid) and simulated (dashed) distribution of the proximity effect strength for our sample of quasars. We mark the position of the mode in the observed distribution and the relative error associated to it. The error bars are computed from the dispersion of the mode in the 500 realisations of the simulated strength distribution (SD).
We also display the value of the UVB computed in the combined analysis of the proximity effect.

The overdensity degree as function of distance

We define the overdensity degree Ξ as the ratio between the effective optical depth corrected for the proximity effect and the one typically expected in the Lyα forest, within a fixed range of 3 Mpc.

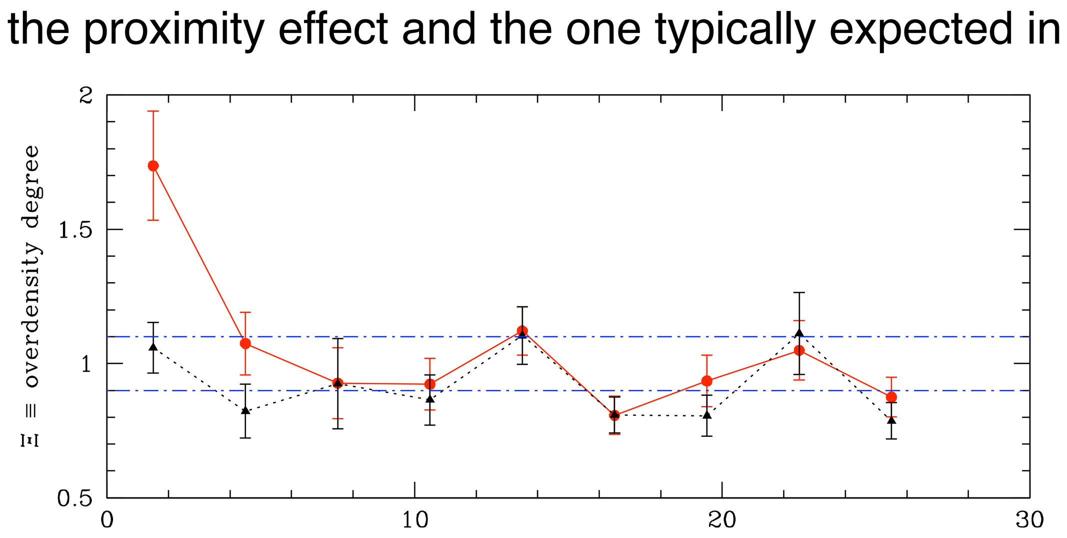


Fig 3.: Average overdensity degree as function of proper distance for the complete sample of quasars (solid line) and in a subsample showing Ξ consistent with no sign of overdensities within 3 proper Mpc from the quasar (dotted line). The two horizontal lines mark the ± 1σ scatter expected from our simulation in the case of no overdense environment.

An unbiased measurement of the UVB

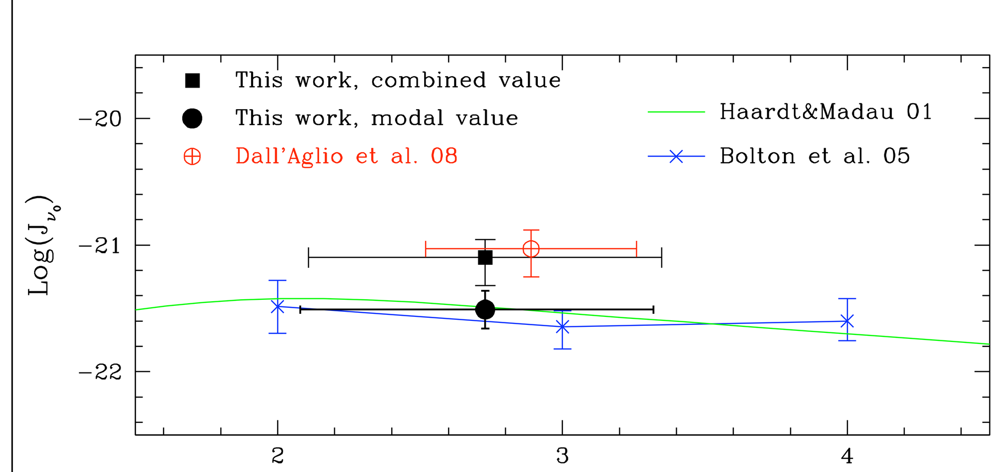
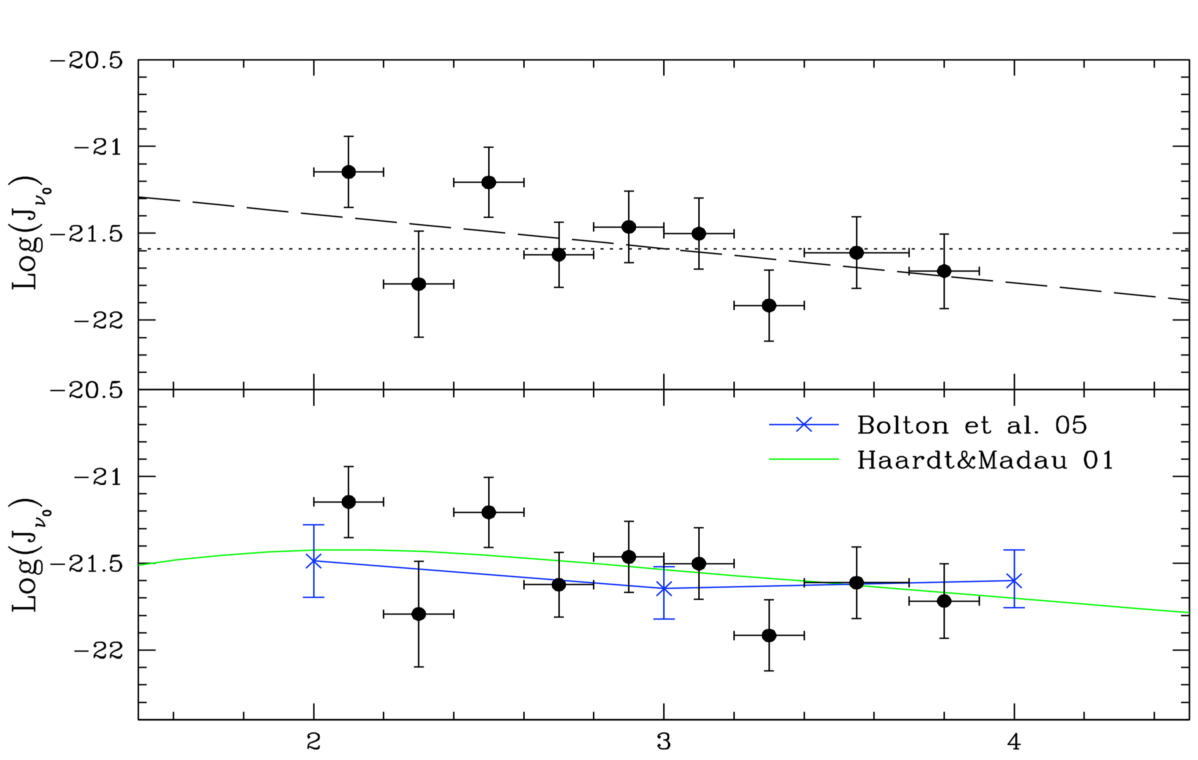


Fig 4.: The UVB estimated from the combined analysis of the proximity effect and the mode of the SD for our sample. We compare our results with the UVB evolution predicted by Haardt & Madau (2001) and with recent estimates by Bolton et al. (2005).

From the mode we infer a mean UVB intensity of log J(ν_0) = -21.51 ± 0.15 in good agreement with the independent estimates. The error bars along the redshift axis represent the lower and upper quartile of the median redshift associated to our quasar sample.

The UVB evolution over the range *2 < z < 4*



We estimate the evolution of the mean UV background intensity over redshift from those quasars with no significant overdensity. We then measure the UVB using the combined analysis of the proximity effect in Δ*z=0.2* intervals over the range *2 < z < 4*.

Fig 5. Top panel: measurements of log J(ν_0) compared to a non-evolving (dotted line) and evolving (dashed line) UV background.
Bottom panel: measurements log J(ν_0) compared to predictions by Haardt & Madau (2001) and the recent determinations from Bolton et al. (2005). The errors in the z direction represent the range used to measure the average UVB.

References

- Bajtlik, S., Duncan, R. C., & Ostriker, J. P. 1988, ApJ, 327, 570
- Bolton, J. et al., 2005, MNRAS, 357, 1178
- Dall'Aglio, A. et al., 2008, A&A, 480,359
- Haardt, F. & Madau, P. 2001, ed. D. Neumann & J. Tran
- Scott, J., et al. 2000, ApJ, 130, 67

*Notation

All measurements of the UV background are expressed in units of erg cm^{-2} s^{-1} Hz^{-1} sr^{-1}