

The transverse proximity effect in spectral hardness

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Science with the new Hubble Space Telescope after
Servicing Mission 4

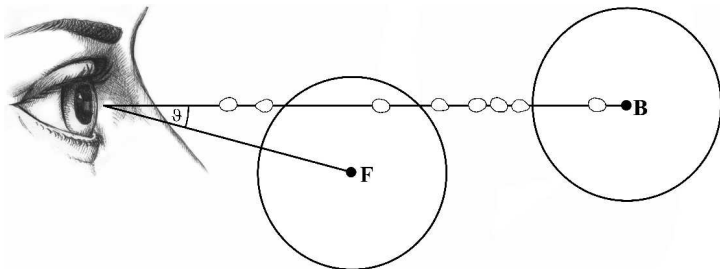
Bologna, January 2008

Outline

- 1 The transverse proximity effect
- 2 Our survey for quasars near quasars
- 3 The hard UV radiation field near quasars
- 4 Conclusions
- 5 Prospects for COS

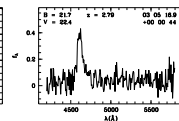
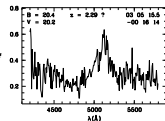
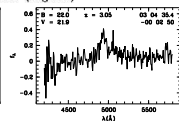
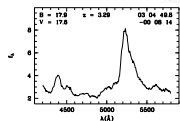
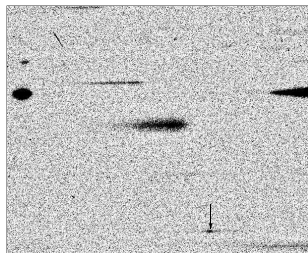
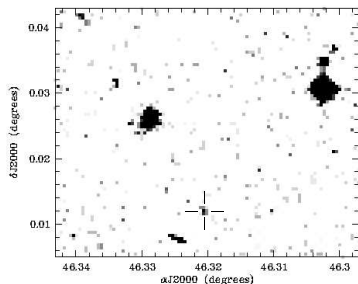
The Transverse Proximity Effect

- intergalactic medium (IGM) photoionized by UV background (quasars & galaxies)
- proximity effect: QSO locally increases UV radiation field
- observables: lack of Ly α absorption lines, increased transmission \rightarrow 5–10 Mpc “void”
- our aim: discover the transverse proximity effect at $1.7 \lesssim z \lesssim 3.6$



Our Survey for Quasars near Quasars

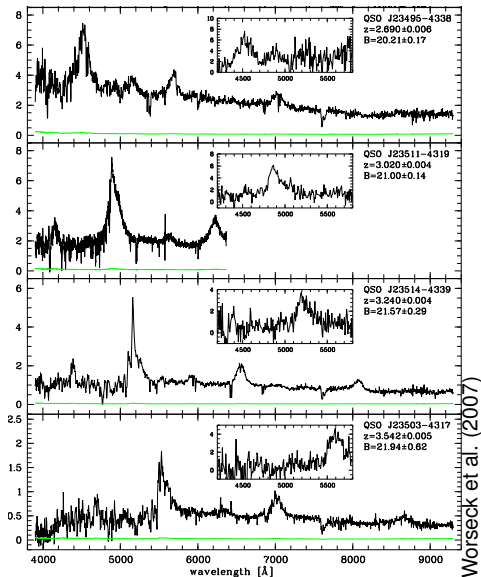
- slitless spectroscopic survey with ESO Wide Field Imager, field of view $25' \times 33'$, spectral range 4200–5800 Å, $V \lesssim 22$
- 18 fields centered on known background QSOs ($2.76 < z < 4.69$)



Worseck & Wisotzki (2006)

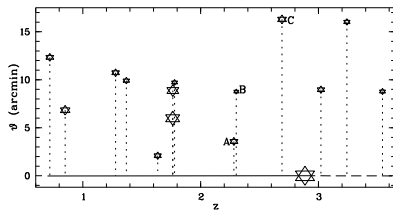
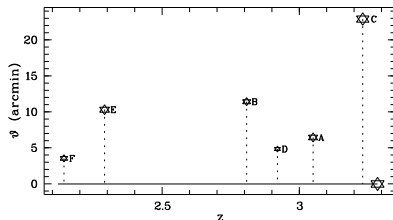
Survey Results

- spectroscopic follow-up with FORS2 at VLT
- 80/81 targeted candidates confirmed
- 64 new $1.70 < z < 3.58$ quasars



The Fields around Q 0302–003 and HE 2347–4342

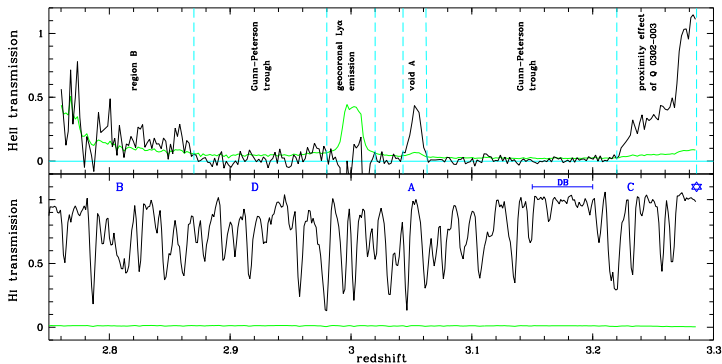
- Q 0302–003 ($z = 3.285$):
6 $z > 2$ foreground QSOs
(2 new discoveries)
- HE 2347–4342 ($z = 2.885$):
3 $z > 2$ foreground QSOs



- two special fields: central lines of sight show intergalactic He II

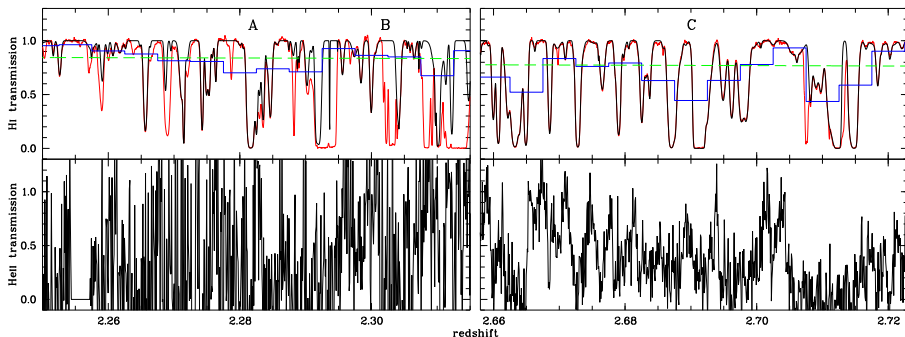
H I and He II Ly α absorption towards Q 0302–003

- He II Ly α at $\lambda_{\text{rest}} = 303.78 \text{ \AA}$ observable in FUV at $z > 2$
- STIS spectrum of Q 0302–003 (Heap et al. 2000)
- He II proximity effect of Q 0302–003
- void A: QSO A reionizes He II (Jakobsen et al. 2003)
- **no obvious transverse proximity effect of other foreground quasars**



H I and He II Ly α absorption towards HE 2347–4342

- FUSE spectrum of HE 2347–4342 at $R \sim 20000$ (Kriss et al. 2001, Zheng et al. 2004)
- post-reionization epoch, He II forest resolved
- again no obvious transverse proximity effect, no large voids

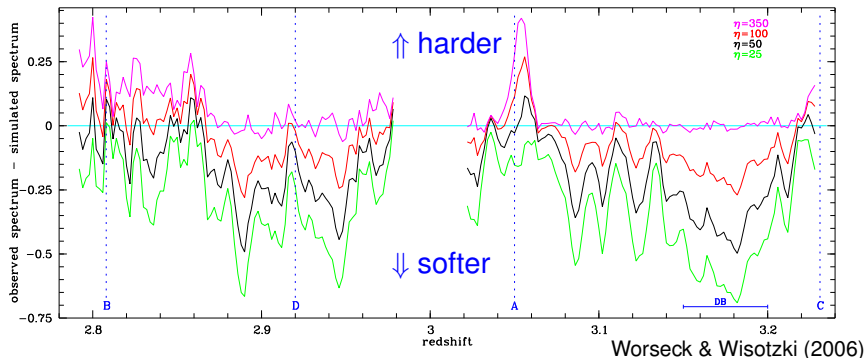


The spectral shape of the UV radiation field

- different ionization energies: H I 13.6 eV, He II 54.4 eV
→ $\eta = N_{\text{HeII}}/N_{\text{HI}}$ measures hardness of UV radiation field
- $\eta \lesssim 100$ for hard radiation from QSOs, $\eta > 100$ requires contribution from galaxies
→ distinguish different ionizing sources along the line of sight
- Q 0302–003: He II absorption unresolved → take (N_{HI}, b, z) from line lists (Hu et al. 1995, Kim et al. 2002), assume η , simulate He II spectrum at STIS resolution, compare data & simulation
- HE 2347–4342: He II forest resolved → η measured by line fitting (Zheng et al. 2004, Fechner & Reimers 2007)

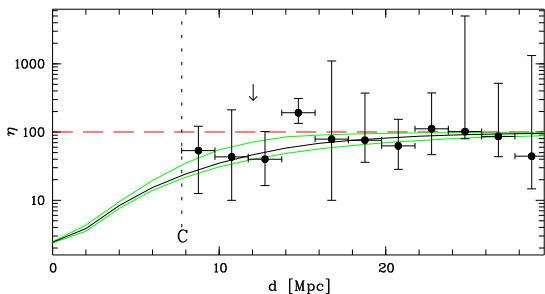
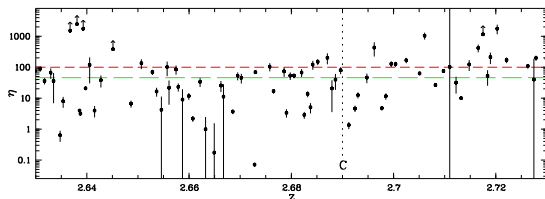
Q 0302–003: hard radiation near 4 foreground QSOs

- hard radiation near Q 0302–003, QSO A & QSO B
- less significant: QSO C & D
- detection of line-of-sight and transverse proximity effect via hardness of radiation



HE 2347–4342: hard radiation near 3 QSOs

- generally: η fluctuates strongly on small scales
- reasons: radiative transfer, small space density of QSOs (Bolton et al. 2006)
- excess of small η values near QSO C and HE 2347–4342**
- hints for similar excess near two other foreground QSOs



Worseck et al. (2007)

- two quasar groups near sightlines with detected He II absorption
- hard UV radiation near central quasars and all 7 foreground quasars
→ radiative feedback of quasars onto IGM on Mpc scales
- spectral hardness is sensitive measure of a weak transverse proximity effect
- spectral hardness breaks overdensity degeneracy near quasars

- high FUV sensitivity \longrightarrow high-quality He II spectra
- known lines of sight: resolve He II forest at $R \sim 20000$
- new lines of sight: characterize the He II reionization at $z \sim 3$
- investigate cosmic variance near He II reionization epoch
- determine spectral shape of the UV background
- correlate UV radiation field with nearby sources