Evidence for a magnitude bias in the Hamburg/ESO Damped Lyα survey

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Multiwavelength views
of the ISM in high-redshift galaxies
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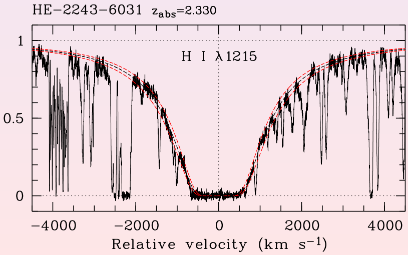
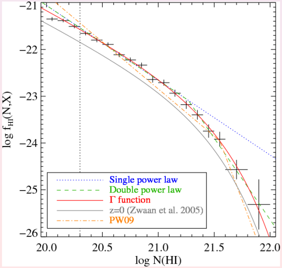
Damped Lyα systems

Damped Lyα systems:

- $\log N_{\rm HI} \geq 20.3$
- from $f(N_{\rm HI})$: contain most of the neutral gas in the Universe
- since $\Omega_{\rm HI} \propto \int_{N_{\rm min}}^{\infty} N_{\rm HI}\, f(N_{\rm HI})\, {\rm d}N_{\rm HI}$, survey for DLAs can determine cosmological density of gas

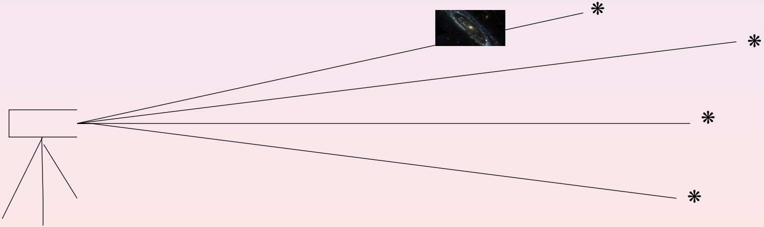
hbox





Survey for Damped Lyα systems

- observe high-redshift QSOs
- search for damped Lyα systems
- sum up their column densities, multiply by the correct factor
- that's it!?



Survey for Damped Lyα systems: biases?

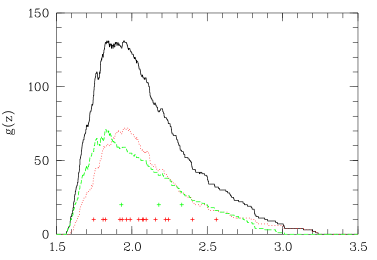
- gravitational lensing: theory predicts a bias, which is a combination of magnification bias and 'by-pass' effect; mainly at $Z \sim 0.7$ for $z > 1$ QSOs (Bartelmann & Loeb 1996; Smette, Claeskens, Surdej 1997): more DLAs should be observed at $z \sim 0.7$ than expected by chance, as QSOs with foreground DLAs are amplified and therefore preferably picked-up in magnitude limited samples;
- dust (Fall & Pei 1997): extinction due to dust increases the apparent magnitude of the background quasar; such quasars could be excluded from magnitude-selected sample.

Hamburg/ESO survey for Damped Ly*alpha* systems

- based on the Hamburg QSO survey:
  - based on blue Digitized Sky Survey, 8000 $\deg^2$
  - objective prism slitless spectra;
  - rather relaxed colour selection criteria, which allow also QSO with moderately red colours;
  - spectroscopic confirmation (ESO 1.5m);
- $z > 1.7$ QSOs observed at medium resolution with ESO 1.5m;
- automatic search for large equivalent widths absorption lines;
- VLT/UVES confirmation for lines with $w_\mathrm{r} > 7.5$Å;
- statistical sample:
  - exclude BAL QSOs;
  - $z_\mathrm{em} > 1.6$;
  - more than 5000 $\mathrm{km\ s}^{-1}$ from emission redshift.

Hamburg/ESO survey for Damped Ly*alpha* systems

- 19 DLAs in 188 QSOs with $<B_\mathrm{J}>= 17.37$;
- $\Delta z = 87.7$; $\Delta\chi = 271$(for ΛCDM);
- $n(z) = 0.22 \pm 0.05$;
- $10^3\Omega_\mathrm{gas} = 1.04 \pm 0.33$; (for ΛCDM);



Hamburg/ESO survey for Damped Ly*alpha* systems

- Important property: probes bright end of QSO LF

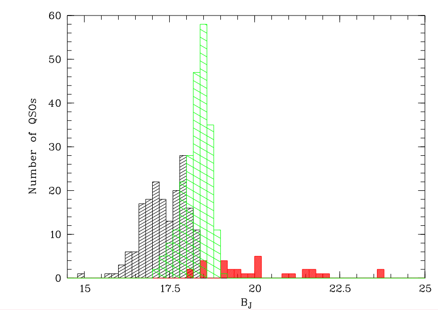


Figure: Bulk of SDSS QSOs have $B_{\mathrm{J}} \sim 19.5$

Evidence for a magnitude bias

We divided sample in 2 sub-samples with (nearly) identical $\Delta\chi$, based on B_J; critical magnitude is $B_\mathrm{J} = 17.4$.

	Whole Sample	Bright Sub–Sample	Faint Sub–Sample
# of QSOs	188	93	95
Δz	87.7	43.6	44.0
$\Delta\chi$	271	134	137
$< B_\mathrm{J} >$	17.37	16.85	17.87
# of DLAs	19	3	16

Poisson statistics: probability to obtain the observed numbers in the 2 sub-samples from the same mean number density is < 0.003.

Evidence for a magnitude bias

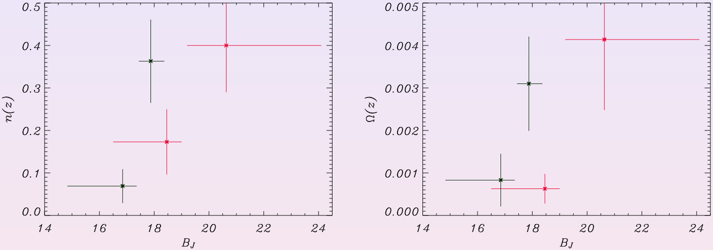


Figure: *Left:* Number densities of DLA systems in the bright and faint sub–samples of the H/ESO survey (black, left–most points) and CORALS (red, right–most points). *Right:* Idem, for the cosmological density of neutral gas.

What is the origin for magnitude bias ?

- General behavior is what people would expect from a dust bias: more DLAs, larger $N_{\rm HI}$ at faint QSO magnitudes.
- However, dust absorption does not know about the background QSOs: dust affects as much the faint and bright samples!
- if QSO number counts is a power law:

$$\log N(< B) \propto B, \tag{1}$$

the effect of dust is

$$\log N(< B) \propto (B - A_{\rm B}) \tag{2}$$

i.e. it shifts the power law to smaller counts, by the same ratio for both the faint and bright samples!

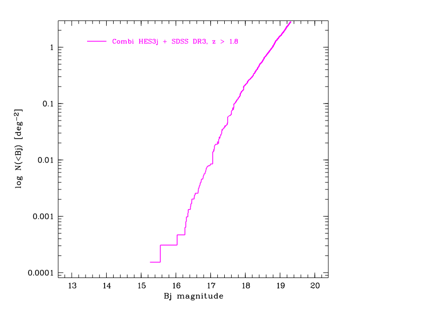
What is the origin for magnitude bias ?

Hamburg/ESO DLA survey

DLAs causing large extinction are rare:

- large $N_{\rm HI}$ are rare: slope of $\log f(N_{\rm HI}) \sim -3$
- if dusty, such DLAs need to be in front of bright QSOs, which are rarer than faint ones!

Way out? the QSO number counts is *not* a power law...



What is the origin for magnitude bias ?

But...does not work numerically!
Even with Milky Way gas-to-dust ratio, only change of $n(z)$ by 50% is possible

Conclusion

- magnitude dependent bias is significant in the H/ESO DLA survey: 16 DLAs in faint sub-sample *vs* 3 in bright sub-sample;
- such magnitude dependent bias is nearly significant in the CORALs,
- but it does not seem to be caused by dust!