Galaxy sizes and environments probed by binary QSOs

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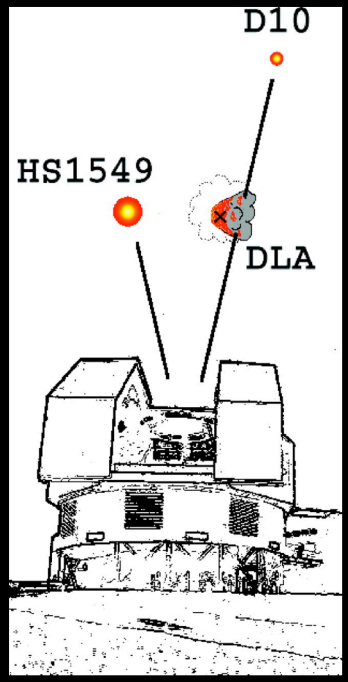
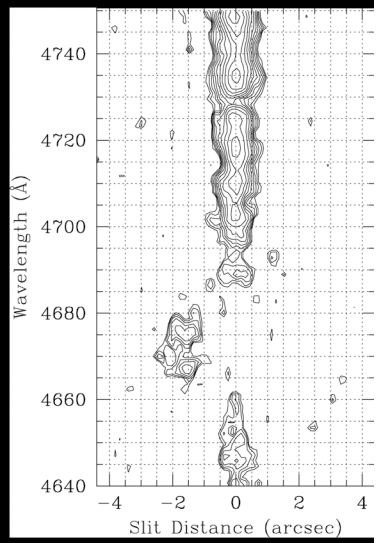
Constraints on DLA Size

1) Direct detection of absorbing galaxies: E.g. Chen & Lanzetta (2003) for 11 z<1 galaxies. $R^* \sim 25$ kpc

2) Extended radio sources: E.g. Foltz et al. (1988), Briggs et al. (1989), sizes ~ 10-15 kpc.

3) Transverse pairs: Fluorescence detected by Adelberger et al. (2006). Separation of fluorescence from QSO gives a lower limit to the size of the absorbing galaxy: 1.5" -> 12 kpc





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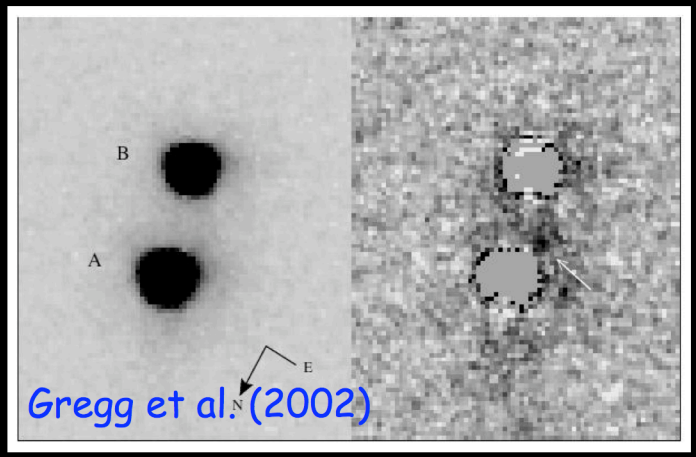
Constraints on DLA Size

4) Lensing coincidences

e.g. HE0512-3329, DLA lensing galaxy (L*) with QSOs probing radii of 2 (A) and 3 (B) kpc (Lopez et al 2005).



Gregg et al. (2002)

QSO	Reference	Separation	Summary
Q0957+561	Churchill et al (2003)	135 pc	DLA / sub-DLA
APM0827+5255	Kobayashi et al (2002)	200 pc	DLA in both LOS
HE0512-3329	Lopez et al (2005)	5 kpc	DLA in both LOS
HE1104-1805	Smette et al (1995)	10 kpc	DLA in 1 LOS only

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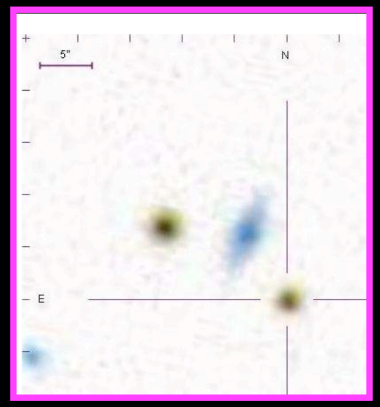
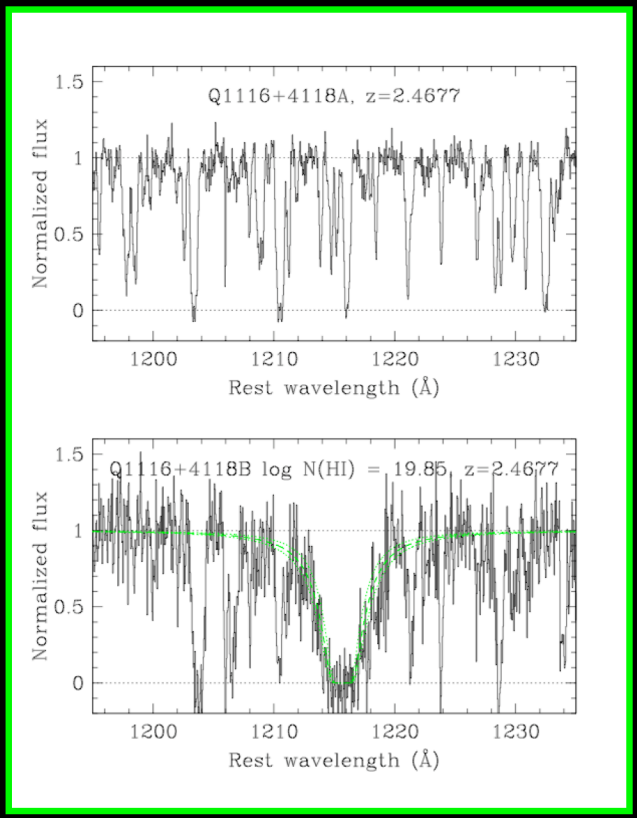


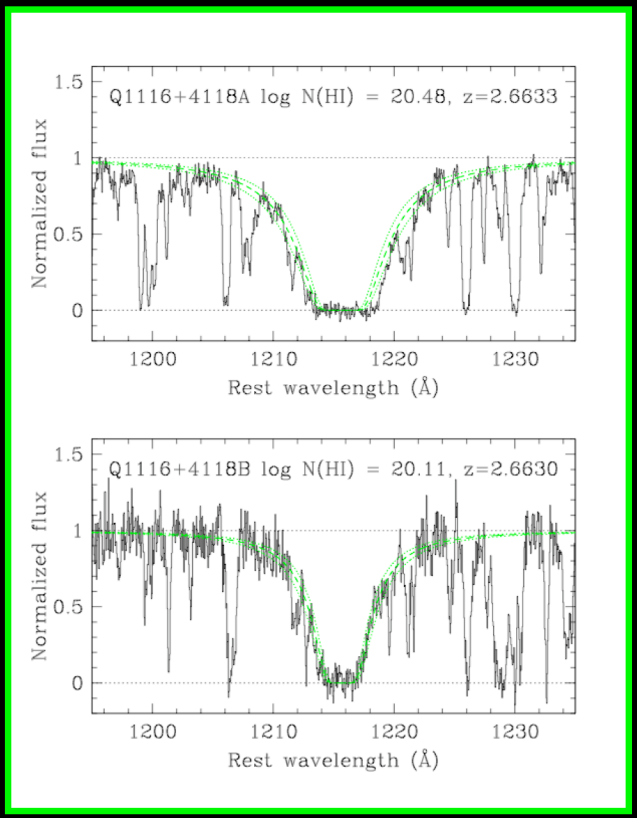
SDSS 1116+4118AB z=2.98, 3.01

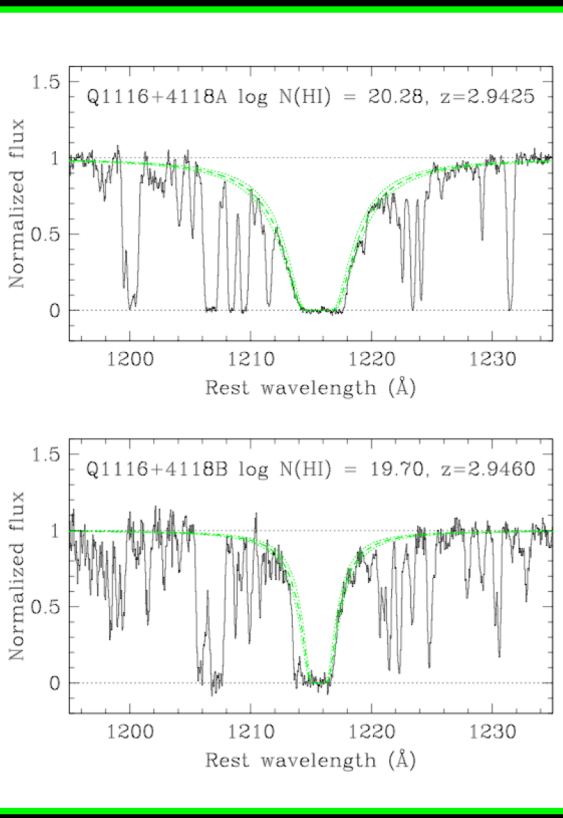
Binary, not lens

ΔΘ=13.8" -> ~110 kpc at z=2.7

Low redshift spiral galaxy at z~0.25







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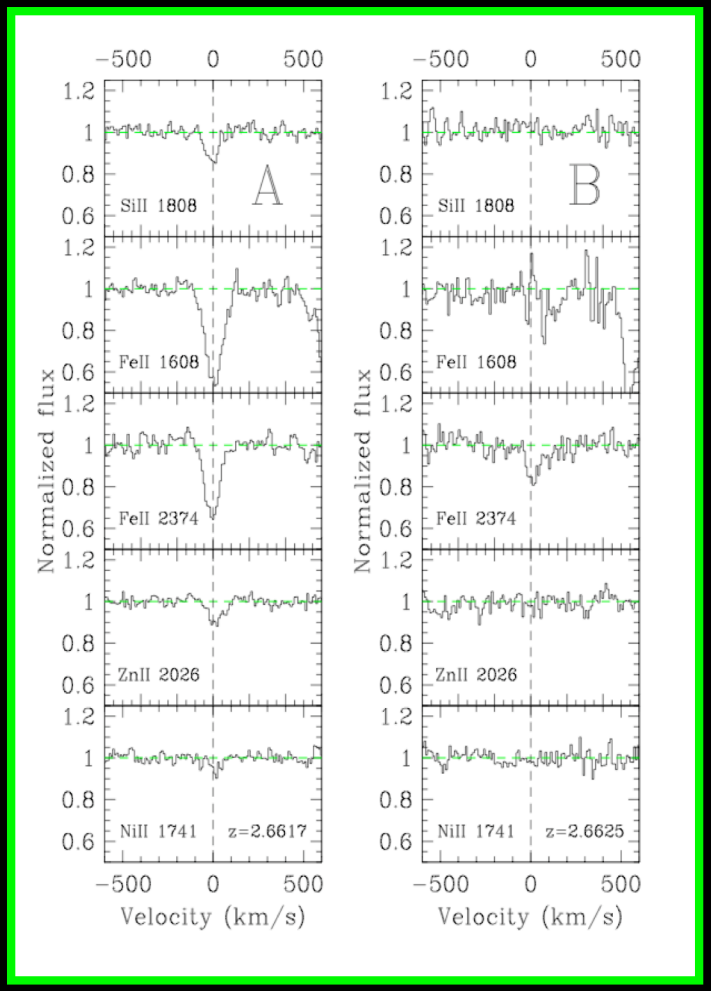
Metal abundances and molecular H_2 fraction



QSO	z_{abs}	N(HI)	[Fe/H]	[Zn/H]	$f(H_2)$
A	2.66	20.5	-1.59	-0.71	...
B	2.66	20.1	-1.71	<-0.51	...
A	2.94	20.3	-1.06	-0.51	<-5.5

At least 2 of the DLAs are metal rich, although even $Z \sim 1/3 Z_0$ does not guarantee H_2.

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Interpretation of coincident absorption

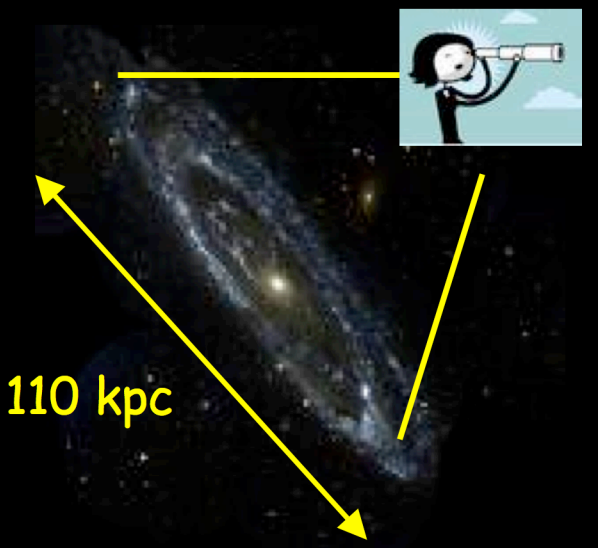
- Clues from relative velocities.

  ΔV = 65 and 340 km/s

  Large, but not inconsistent with high z rotation curves

- Clues from metallicities.

  High metallicities indicate sightline is not hitting galaxy in its outer part, I.e. 100 kpc is unlikely to be a diameter.



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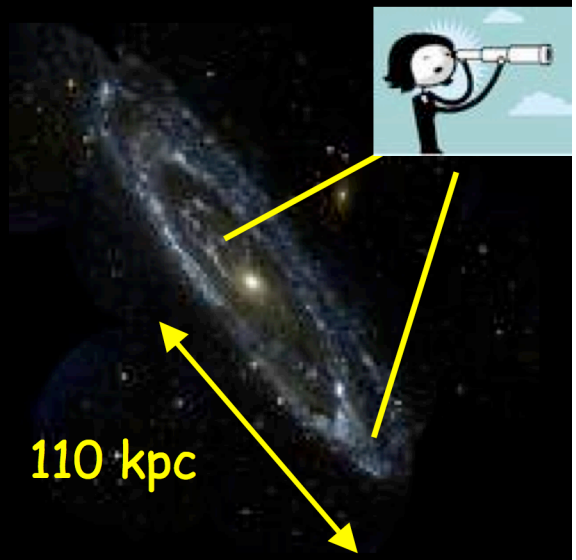

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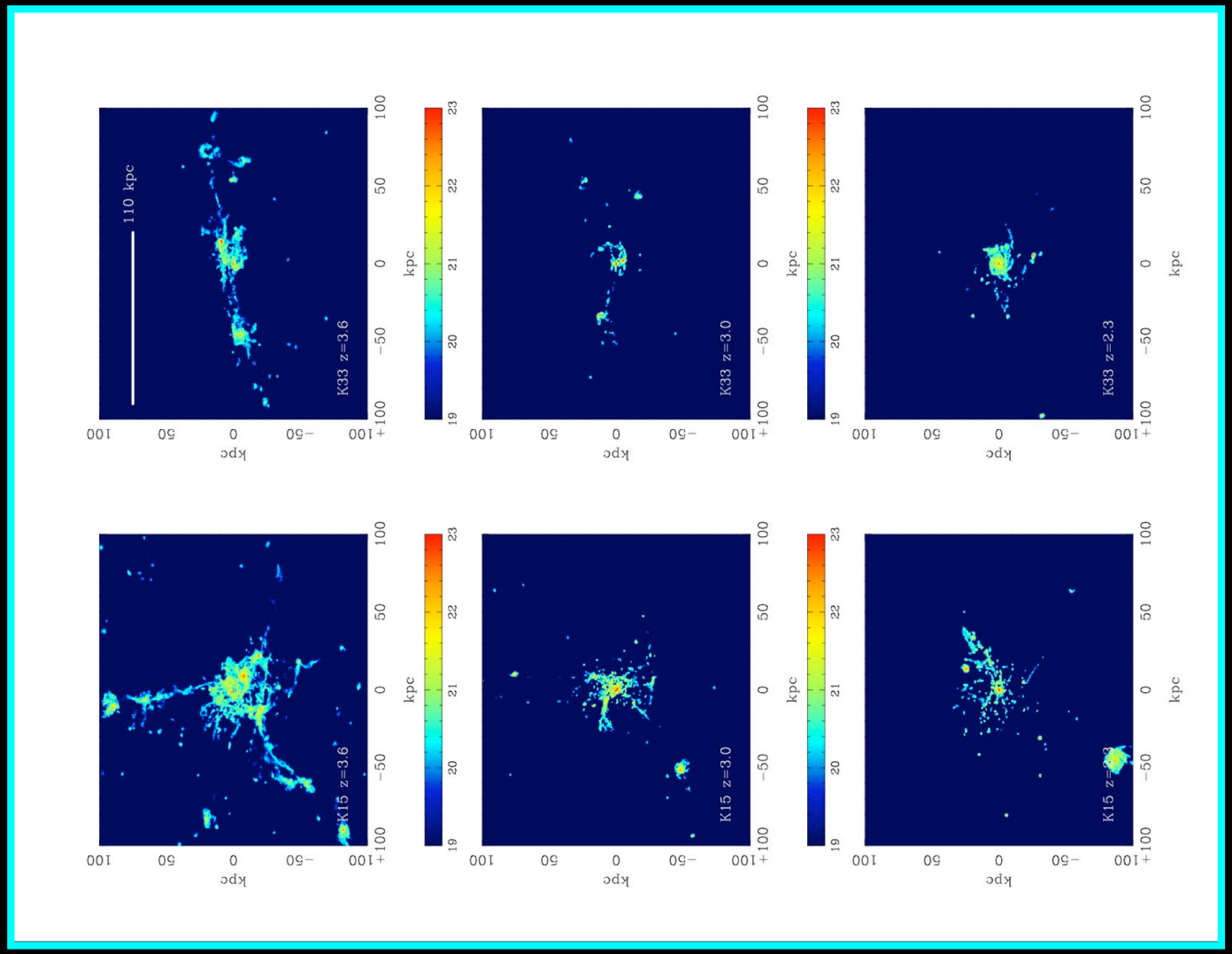
Insight from simulations



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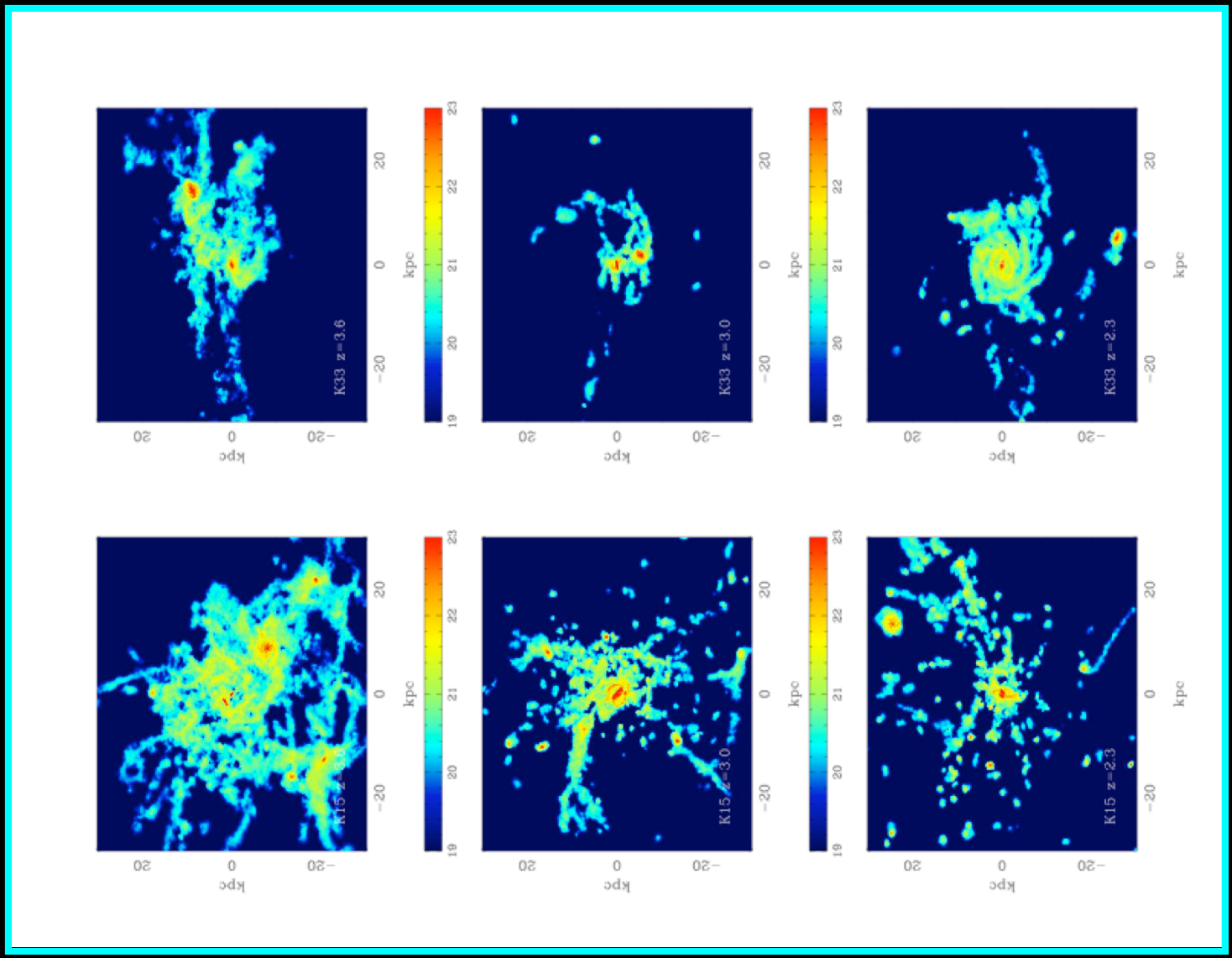

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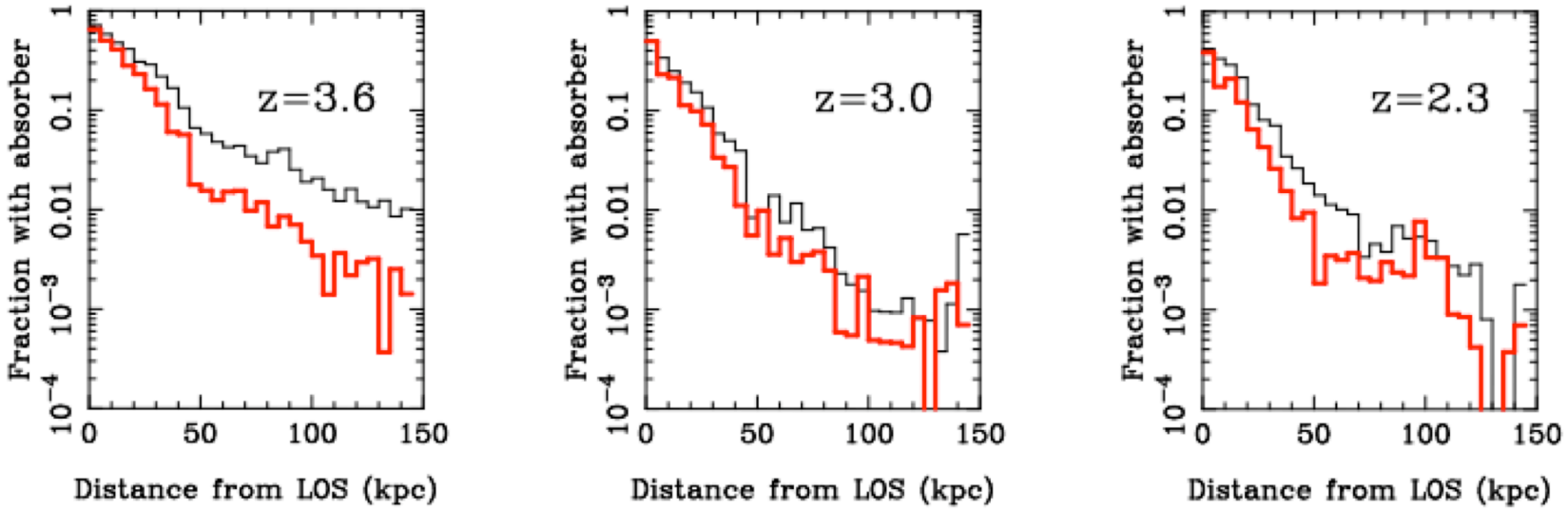

The fraction of double sightlines with coincident absorption. Double DLAs shown in red, double sub-DLAs in black. Probability of two double hits ~10^{-5}. However, one of the absorbers is a proximate DLA which have been shown to cluster around the QSO.

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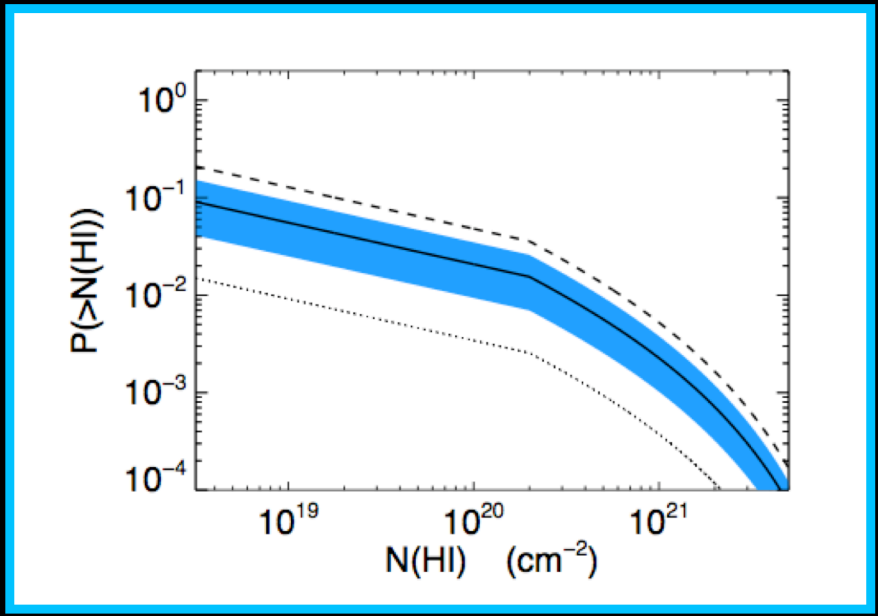
Is coincident absorption in a group?



Clustering analysis: Use the correlation function of LBGs and DLAs of Cooke et al. (2006). Combine this with HI column density distribution function to determine the probability of finding coincident absorption within ΔV=400 km/s and $\Delta\Theta$=13.8". Probability of a double sub-DLA ~ 8%.

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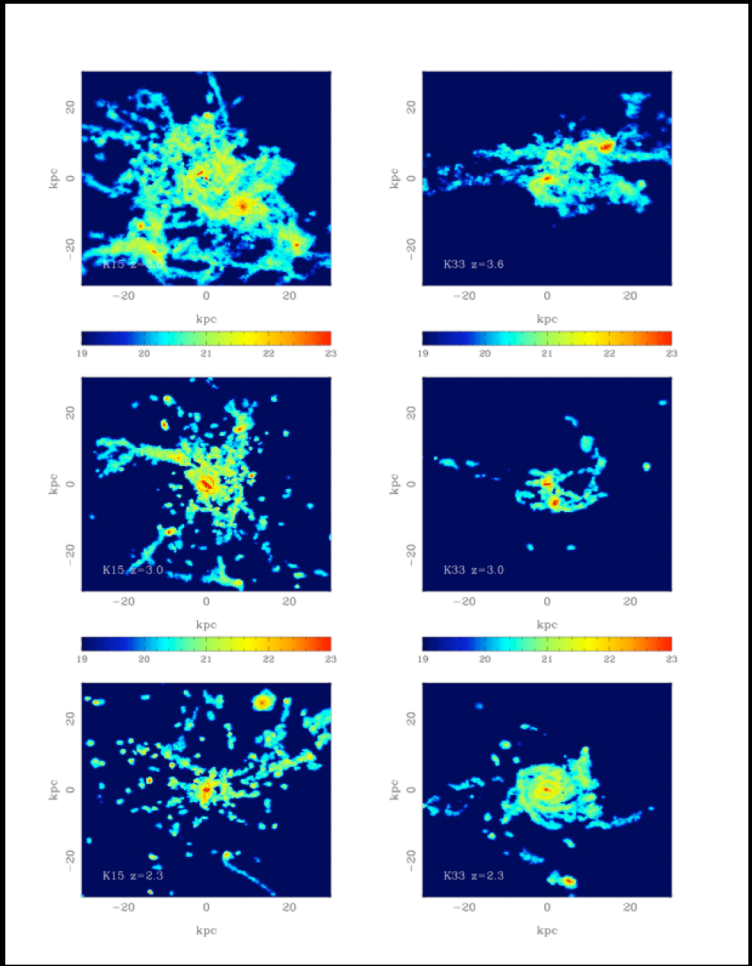
Future observations to constrain DLA size



Using a `hits and misses' maximum likelihood analysis for a statistical DLA size. Simulations indicate that ~50 pairs needed if $\Delta\Theta<4''$ ($r<30$ kpc), or 20 if $\Delta\Theta<3''$ ($r<20$ kpc). Very close binaries are therefore required to determine DLA size.

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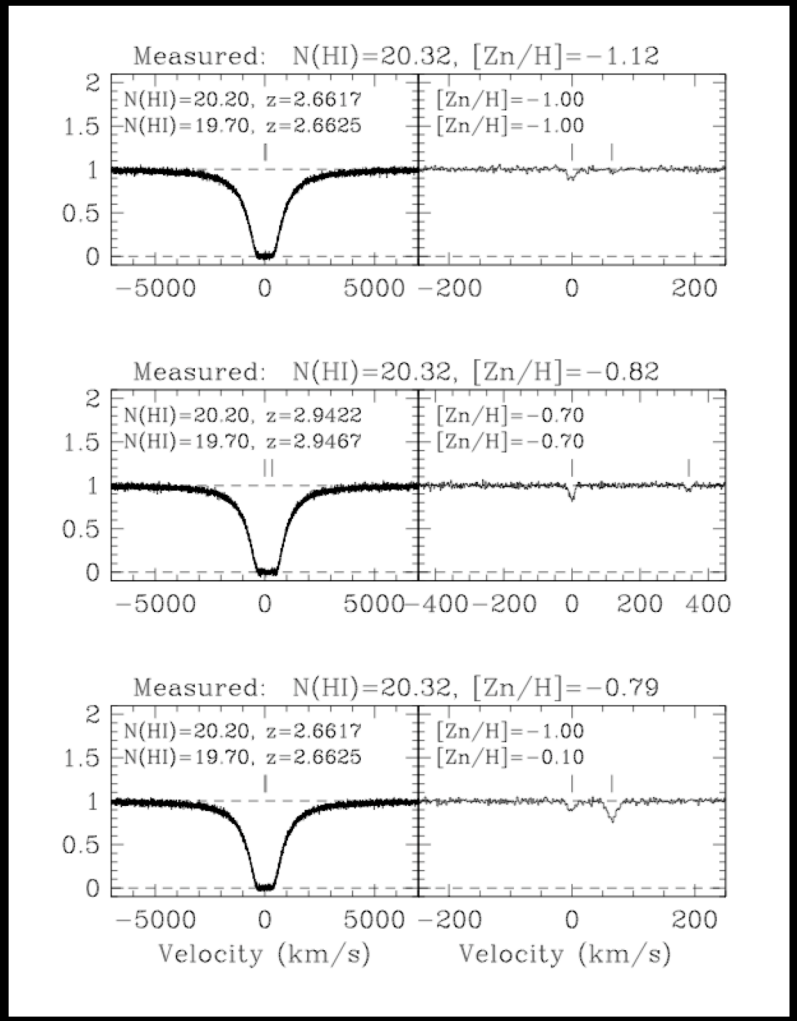
Implication for single line of sight DLAs



Blended absorption not discernible in HI for Δ V<1000 km/s. If coincident absorption is common in single lines of sight, metallicities may be wrong by ~0.2 dex and velocity structures difficult to interpret.

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Summary

- Binary sightlines offer a promising way to probe DLA sizes, environments and abundance structure.
- Coincident absorption in z~3 binary with 110 kpc separation unlikely to be single absorber. Group?
- DLA sizes best constrained with separations $\Delta\Theta$ <3". Maximum likelihood tests require ~20 such sightlines.
- If DLAs are strongly clustered, single line of sight observations may have errors in metallicities.

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