In search for the ‘ideal’ system to constrain the variations of constants

-> DLAs in the SDSS

-> 21 cm absorbers

-> Molecular Hydrogen in z>1.8 DLA systems

Patrick Petitjean

Institut d’Astrophysique de Paris

P. Noterdaeme (Universitad de Chile)

C. Ledoux (ESO)

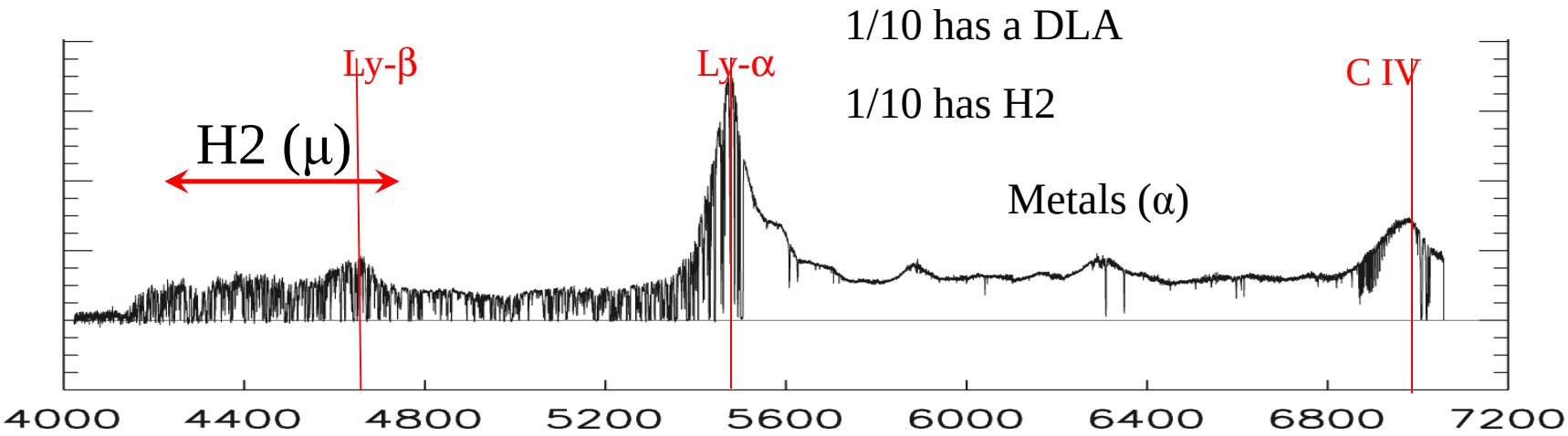
A. Ivanchik (Ioffe Institute, Petersburg)

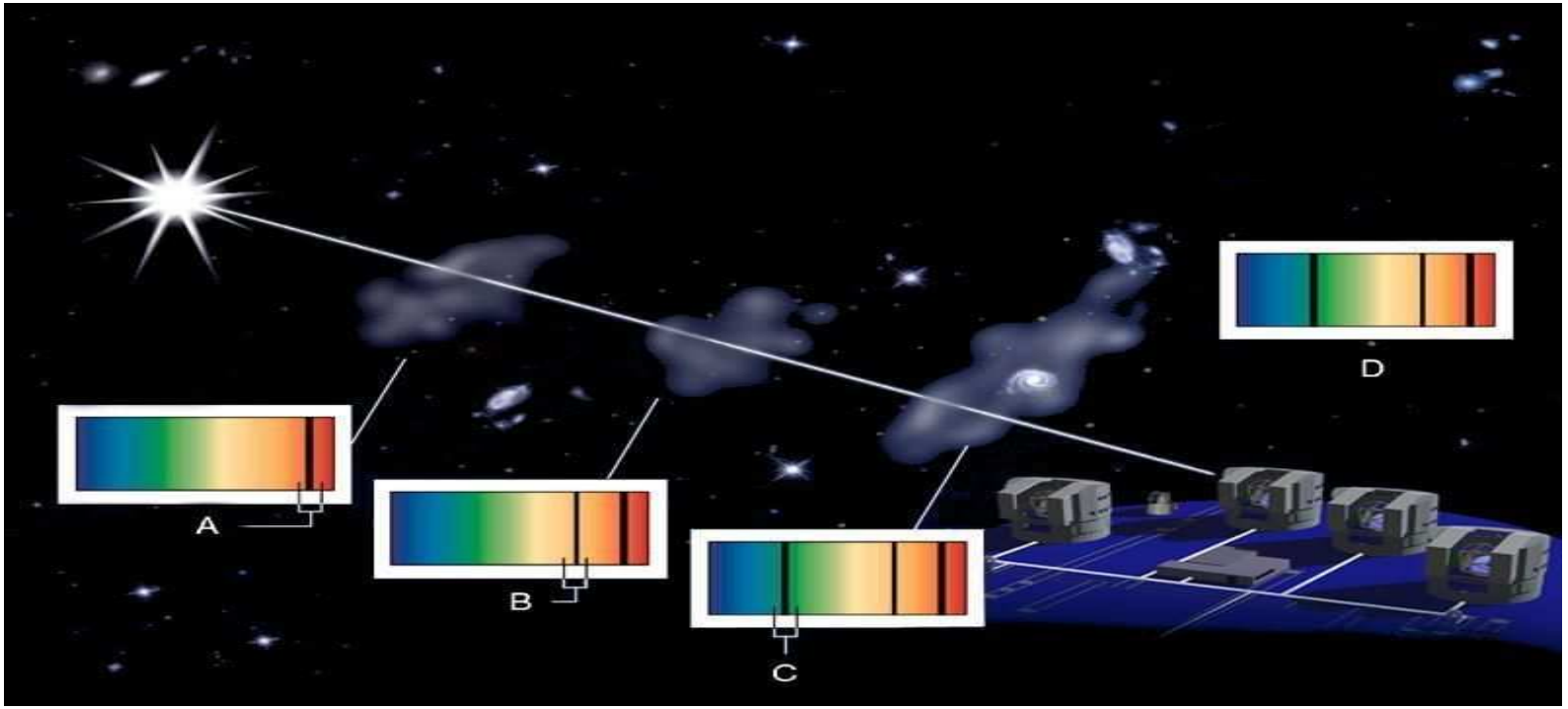
R. Srianand (IUCAA, India)

N. Gupta (NCRA, India)

No variation of α in the North ?

Quasar Absorption Lines -> Diffuse IGM and dense ISM





Cosmology with the GMRT

Search for 21cm in MgII systems

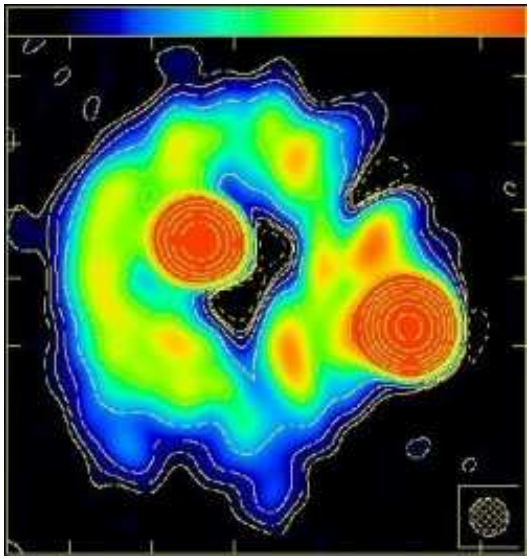
Measurements in the Radio

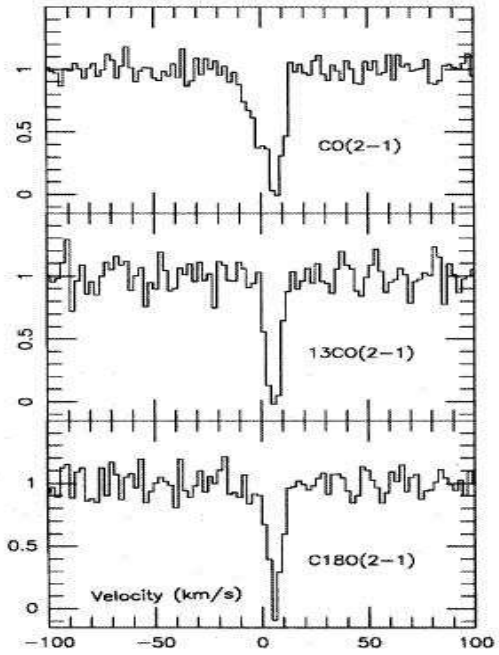
HI 21cm absorption + UV lines : Higher accuracy

Lenses strongly absorbed : B0218+357 at z=0.685 CO, HCO+…
PKS1830-211 at z=0.886 +HI

PKS1413+135 at z=0.247 OH conjugate

Systematics
+
Very few systems
+
Low z





Measurements in the Radio

B0218+357 at z=0.685 CO, HCO+… + HI
PKS1413+135 at z=0.247
$\Delta y/y=-0.18\pm0.50\times10^{-5}$
$y=g_p\alpha^2$ Murphy et al. 2001, MNRAS, 327, 1244

B0218+357 at z=0.685 CO, HCO+… + NH3
$\Delta\mu/\mu < 2.7\times10^{-6}$ 3σ Murphy et al. 2008, Science, 320, 1611

PKS1413+135 at z=0.247 OH conjugate
$\Delta G/G=-1.18\pm0.46\times10^{-5}$ $\Rightarrow \Delta\alpha/\alpha=-3.1\pm1.2\ 10^{-6}$
$G=g_p(\mu\alpha^2)^{1.85}$ Kanekar et al. 2010, ApJ 716, 23

Quasar Absorption Lines -> Diffuse IGM and dense ISM

- UV Lines : MgII, FeII, SiII etc… (in the optical)

  -> α

- H2 and other molecules HD (in the UV)

  -> $\mu=m_p/m_e$

- 21cm absorber (in the radio)

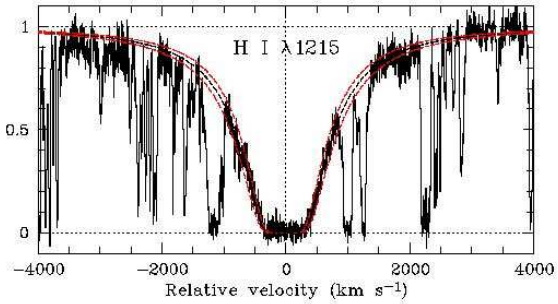
  -> $x=\alpha^2 G_p/\mu$

The ideal system : H2+HD, UV and 21cm

* Find quasars
* 10% have a DLA: 1000 DLAs known
* 10% have H2 (10% have HD)
* Very few have 21cm (radio quasars)

Damped Ly-α Systems

HI :



Metals :

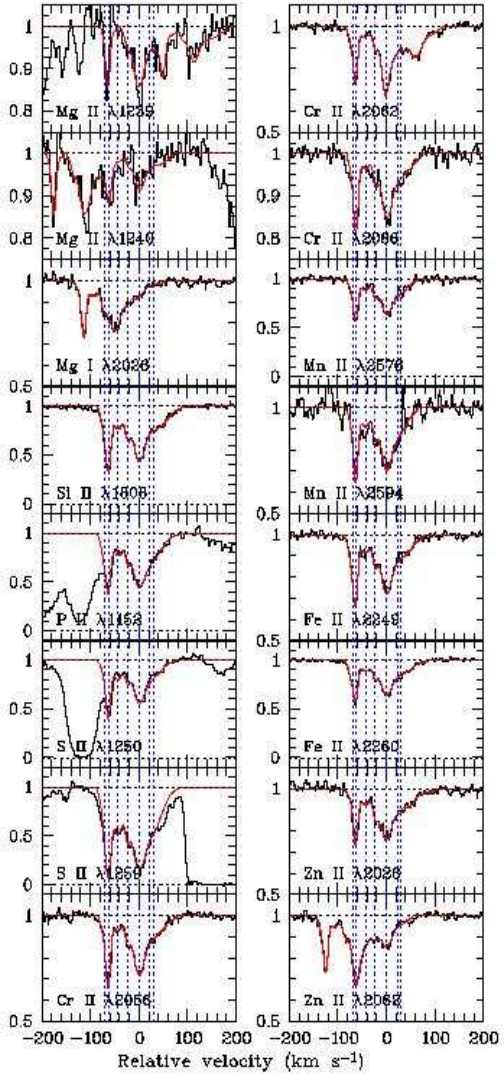
-> Metallicities

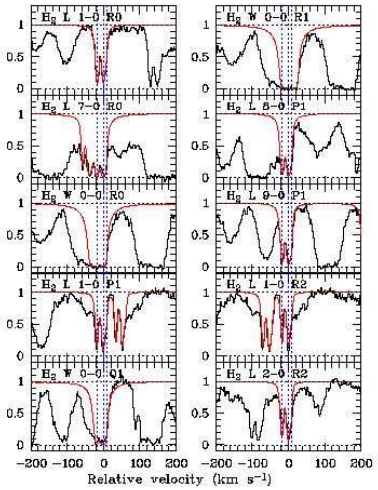
-> Dust content

-> Kinematics

Star- Formation ?

Winds ?





Molecules H2 + CI, CI* :

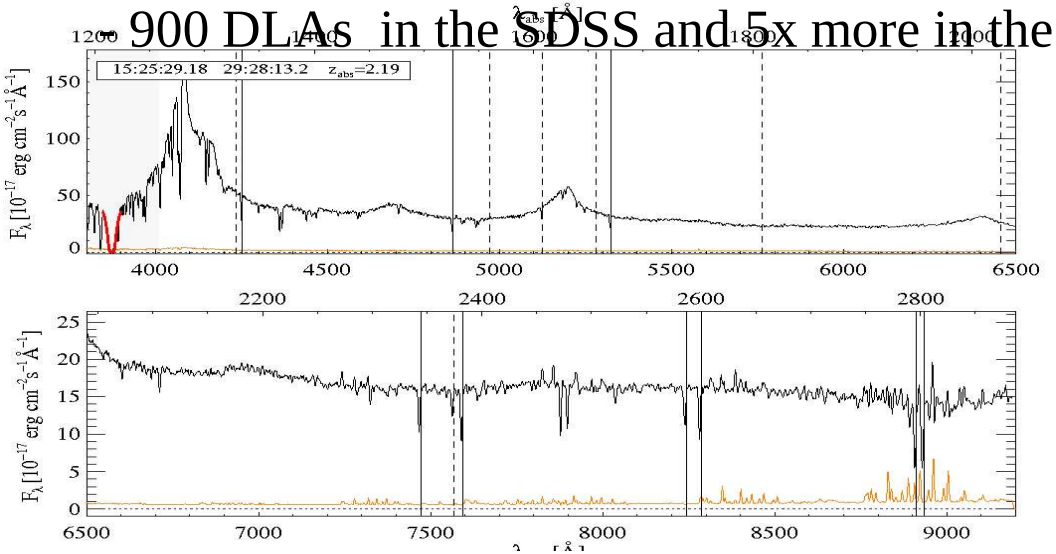
-> Density/Temperature

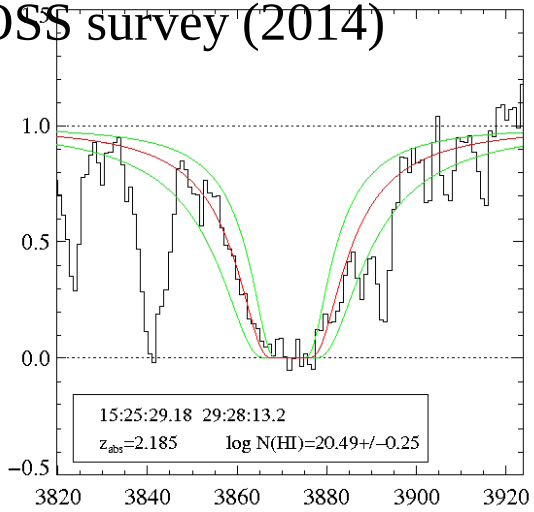
-> UV flux (excitation)

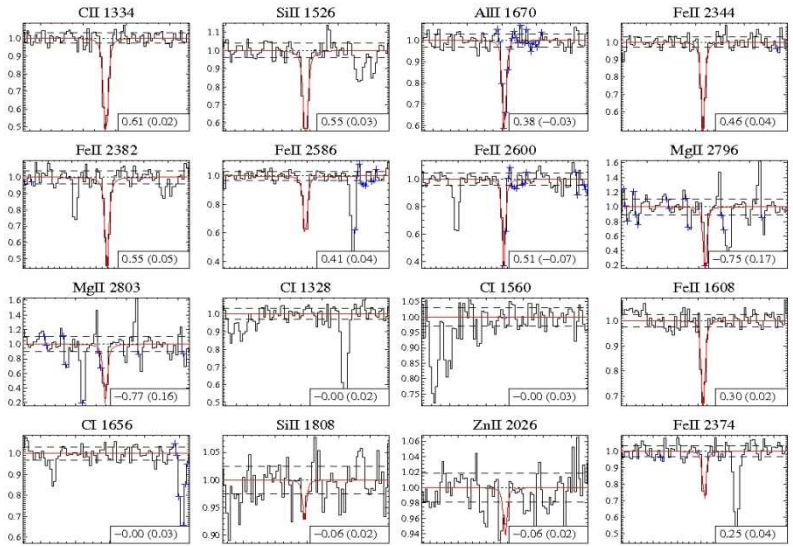
Search for DLAs in the Sloan Digital

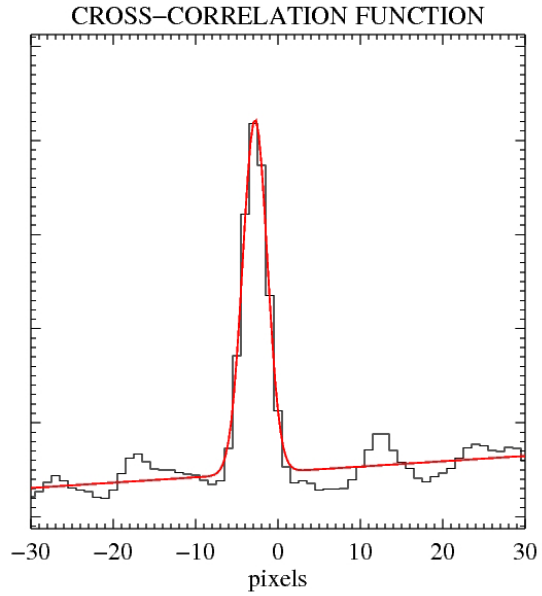
-Search the 11,000 SDSS quasar spectra for DLAs : Fully automatic procedure

- 900 DLAs in the SDSS and 5x more in the BOSS survey (2014)



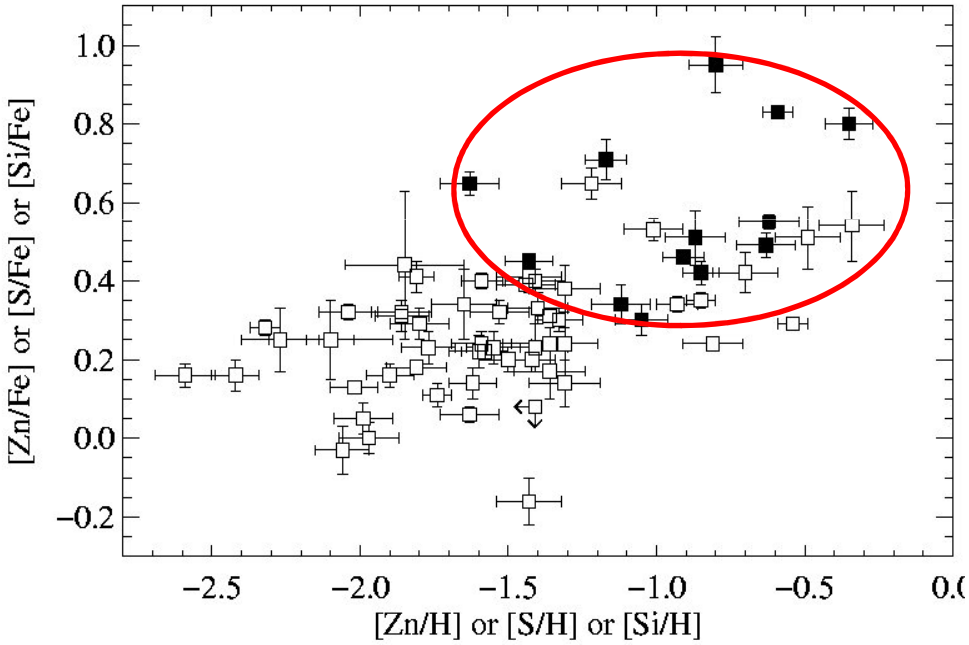


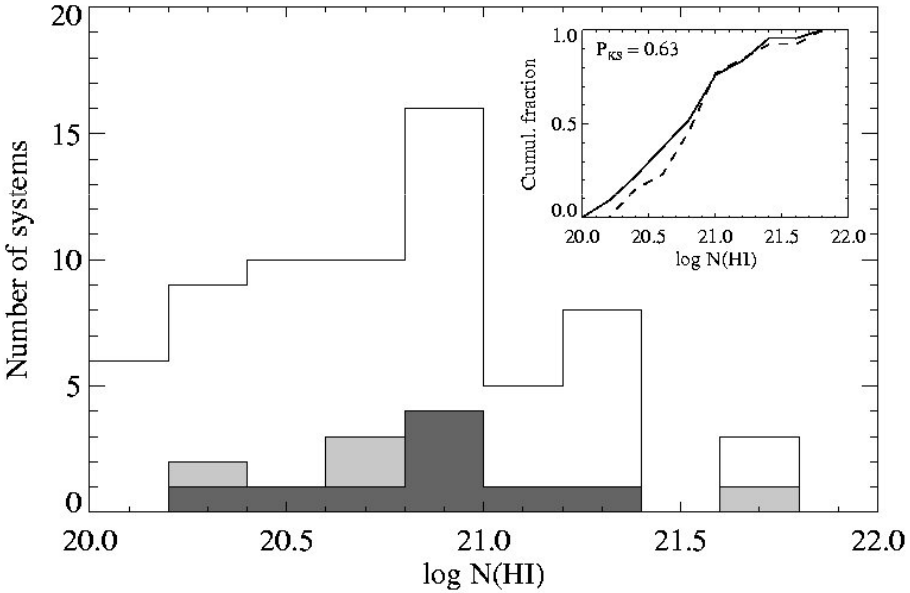




DLAs with H2: Presence of dust Not HI : 50 UVES nights

- Correlation Depletion ([Zn/Fe]) vs Metallicity ([Zn/H])
- Presence of H2 is NOT correlated with NHI

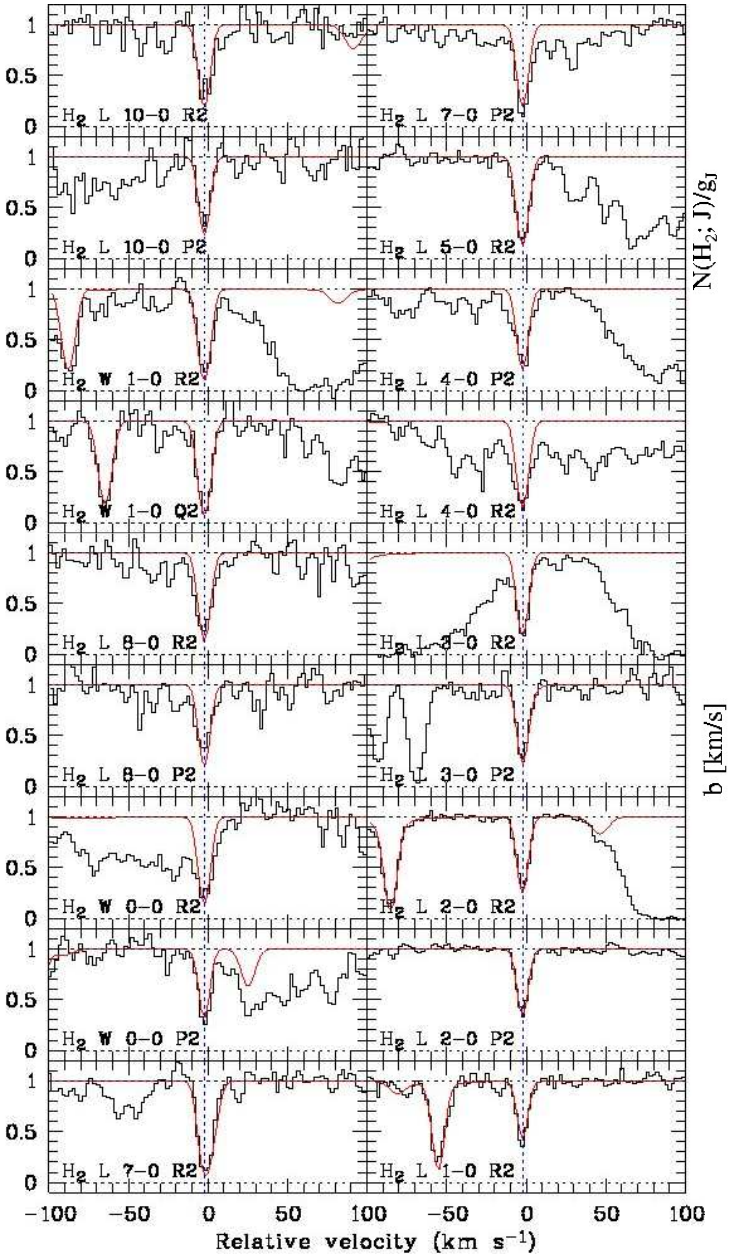


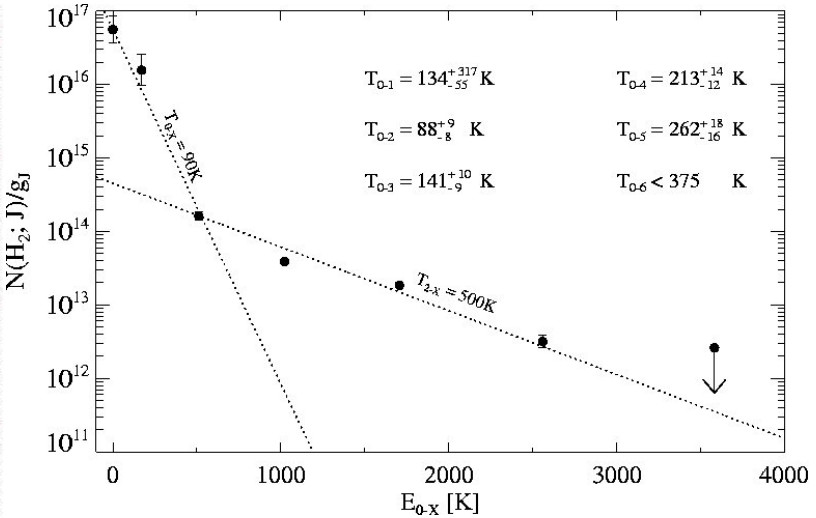


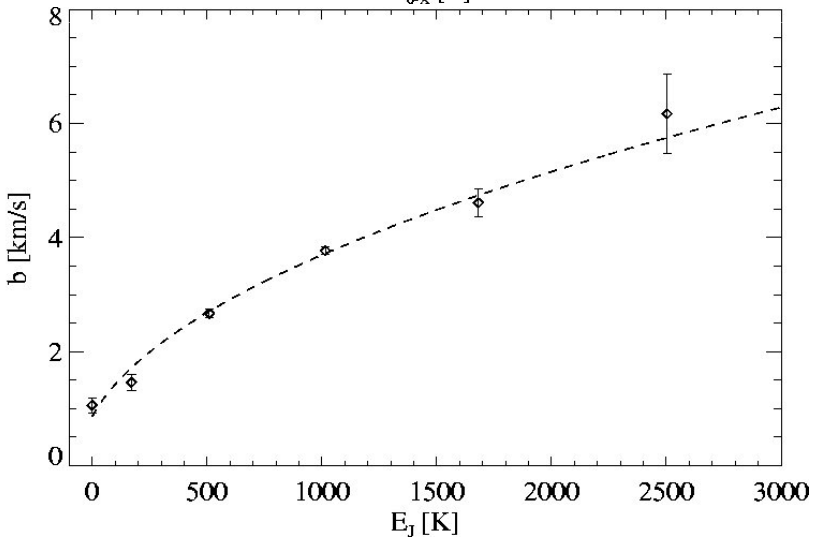
SDSS search : Noterdaeme et al. 2009, A&A, 505, 1087

UVES survey : Noterdaeme et al. 2008, A&A, 481, 327

H2 absorption lines to be used to constrain μ







2 components ?

No shift – Ad'hoc

⇒New Heating Process

Different widths

Doppler parameter increases with J

HE0027-1836 : Noterdaeme et al., 2007, A&A, 469, 425

Search for molecules

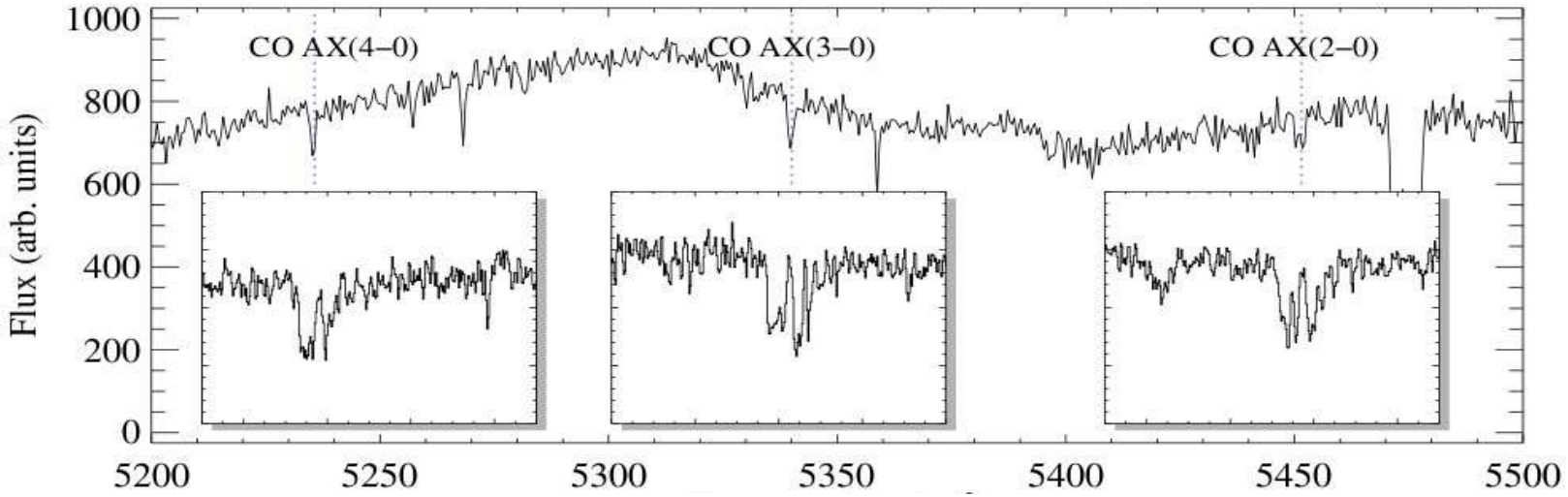
Selection H2: *** High dust content (depletion)

** High metallicity

* High NHI

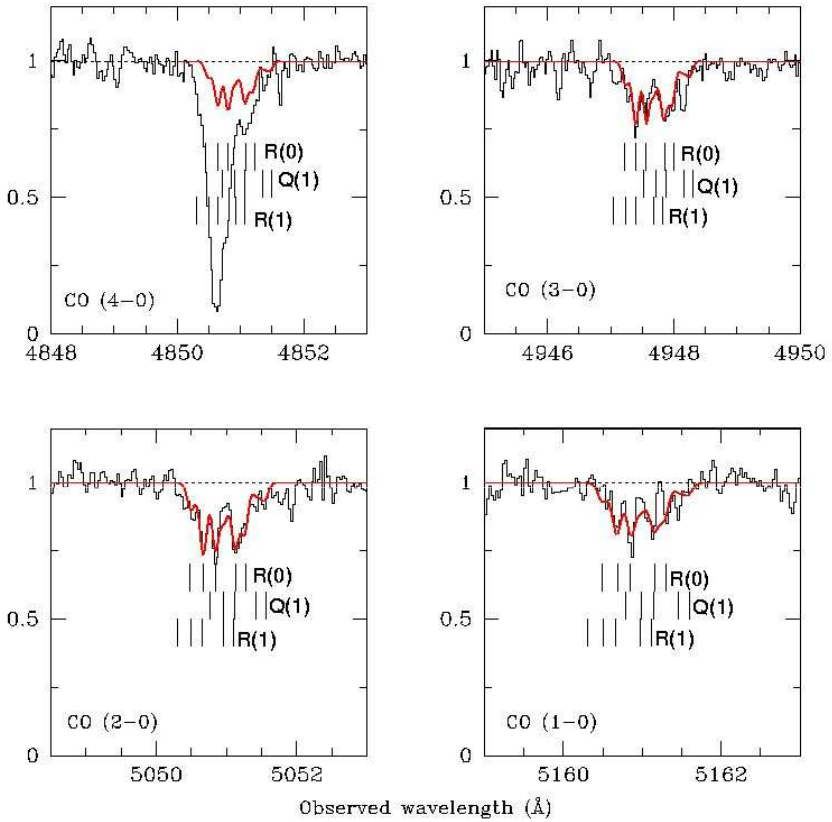
Other Molecules: CO + HD

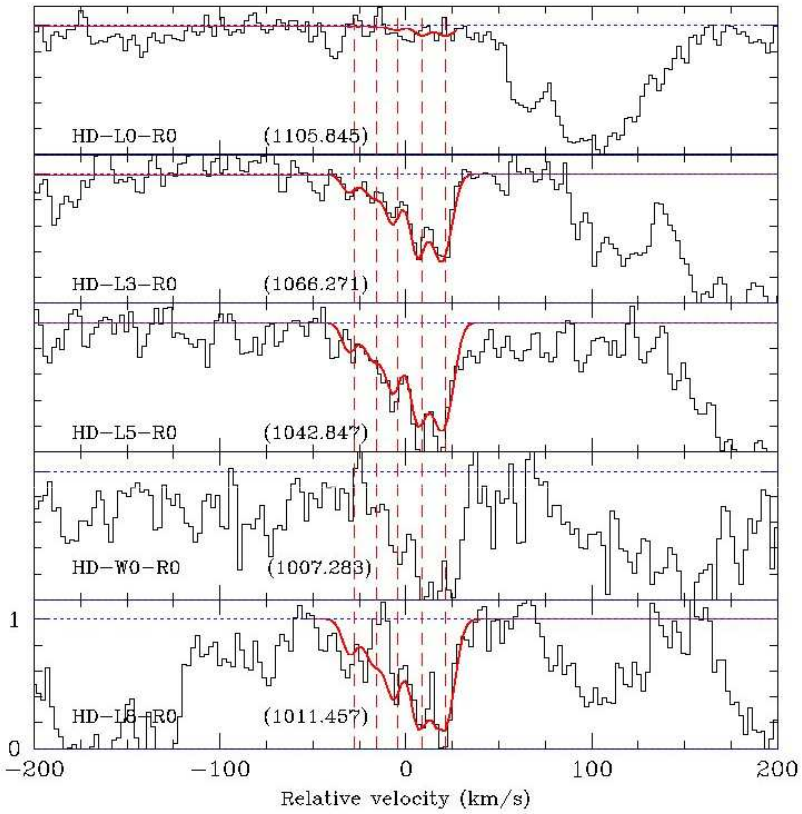
Selection by CI : X-shooter survey+ follow-up UVES



CO and HD -> 6 detections

z=2.42 ; [S/H]=-0.07; [Fe/S]=-1.33





Log(f) = -0.3 (highest in DLAs) ; CO/H2 = 3×10^{-6}

HD/2H2 = 1.9×10^{-5} (>Galactic local ISM) -> Low astration

Srianand et al. (2008) A&A, 482, L39 - Noterdaeme et al. (2008) A&A, 491, 397

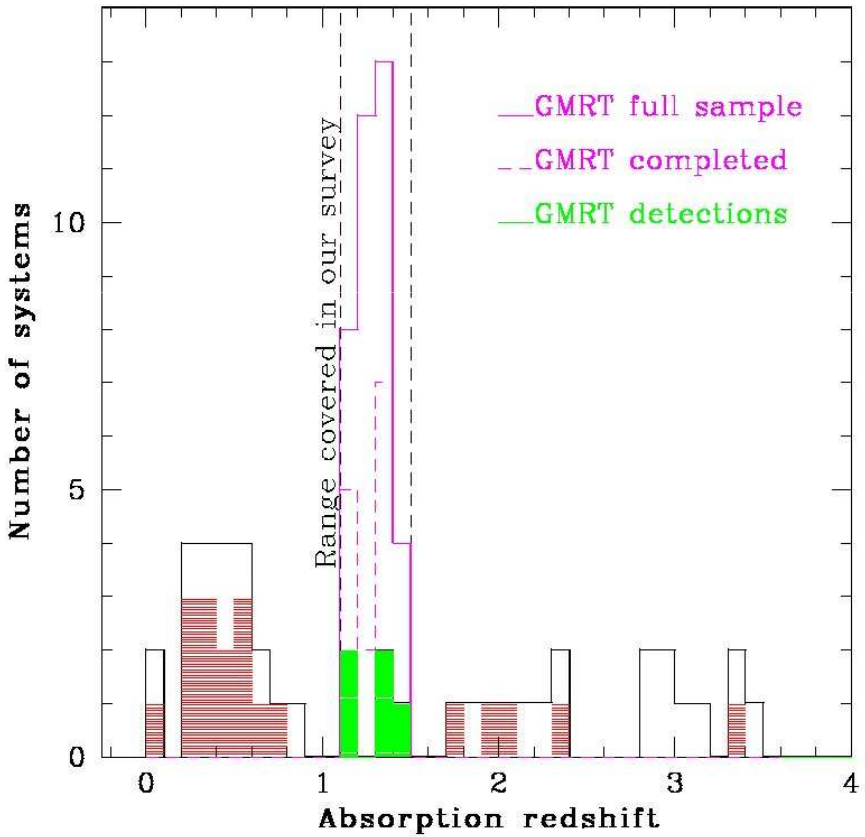
Cosmology with the GMRT

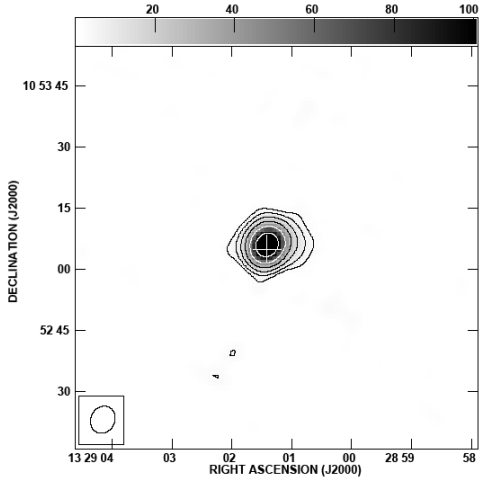
Search for 21cm in MgII systems

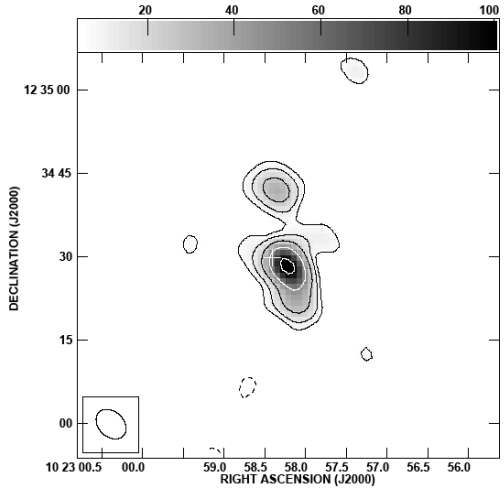
SDSS-GMRT Sample of ~50 MgII Systems

300 hours of GMRT

Very few systems

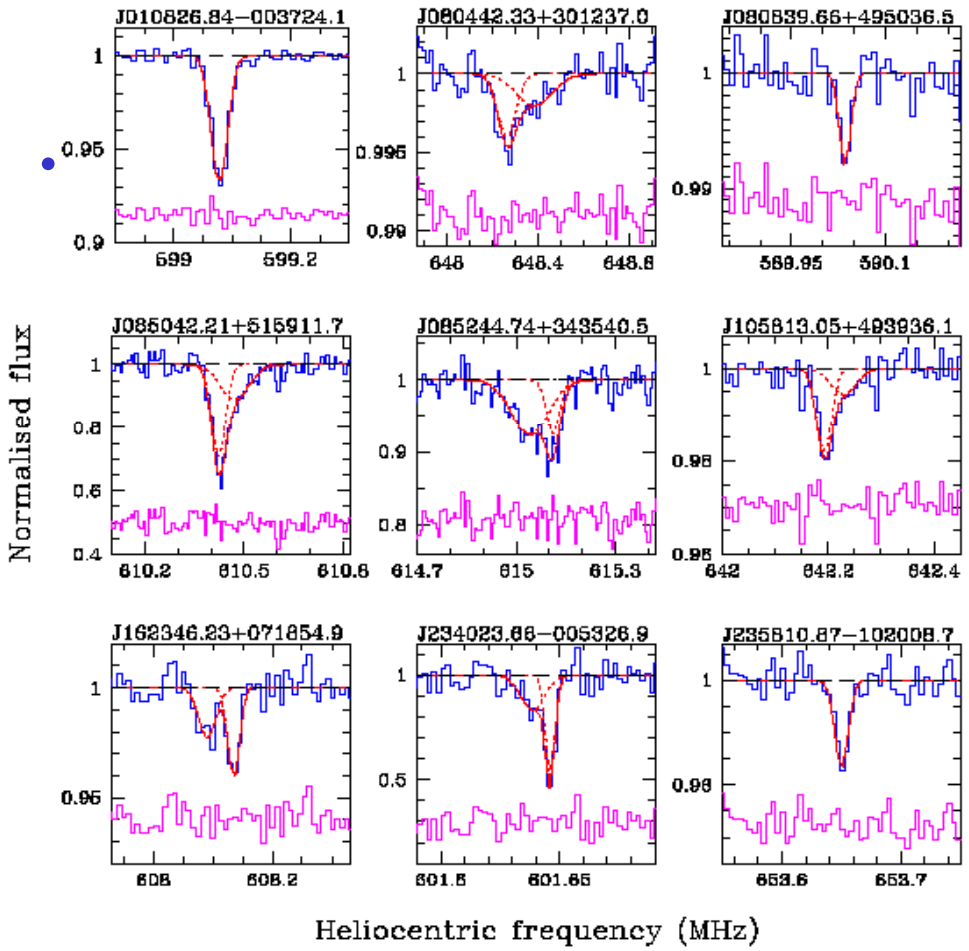






Size of the source ?

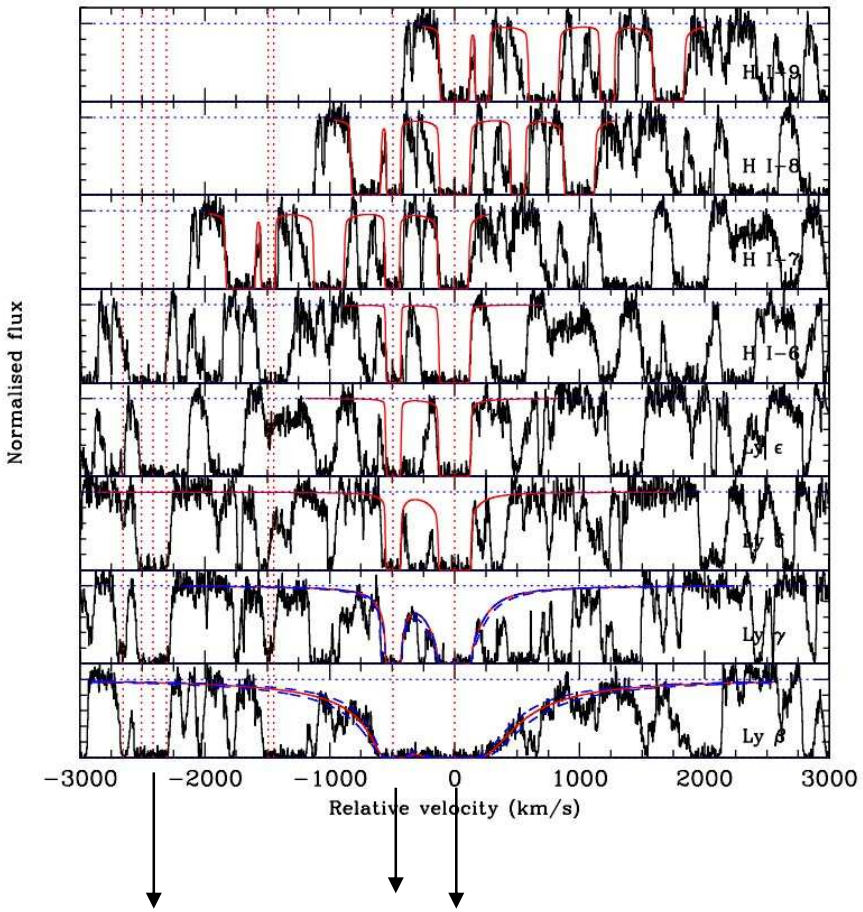
Nine new detections

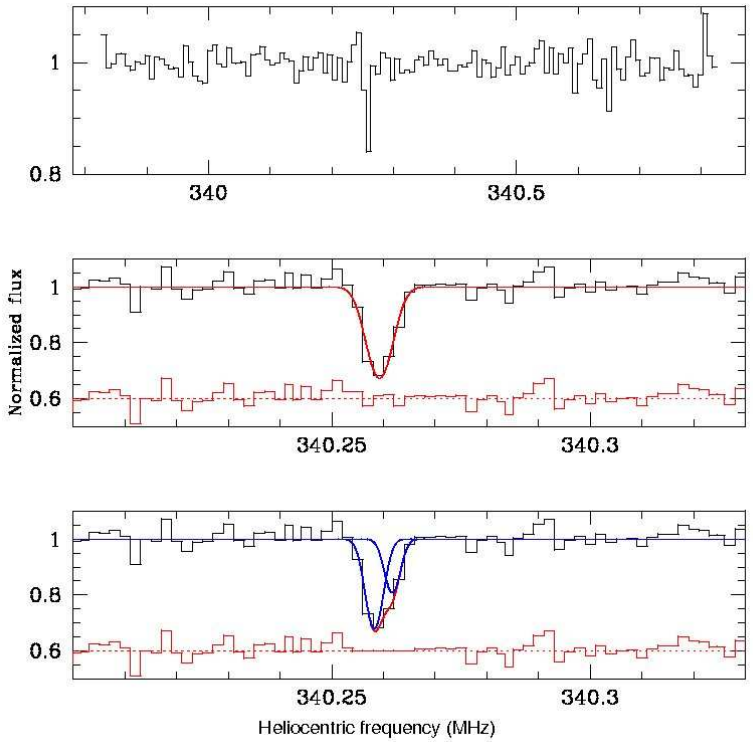


- High resolution : 1 km/s
- Delta v small < 100 km/s
- Well defined component

Gupta et al. 2009, MNRAS, 398, 201

DLA toward J1337+3152 (z=3.17)





21cm absorption (GMRT)

z=3.174492(7) FWHM=3.4km/s

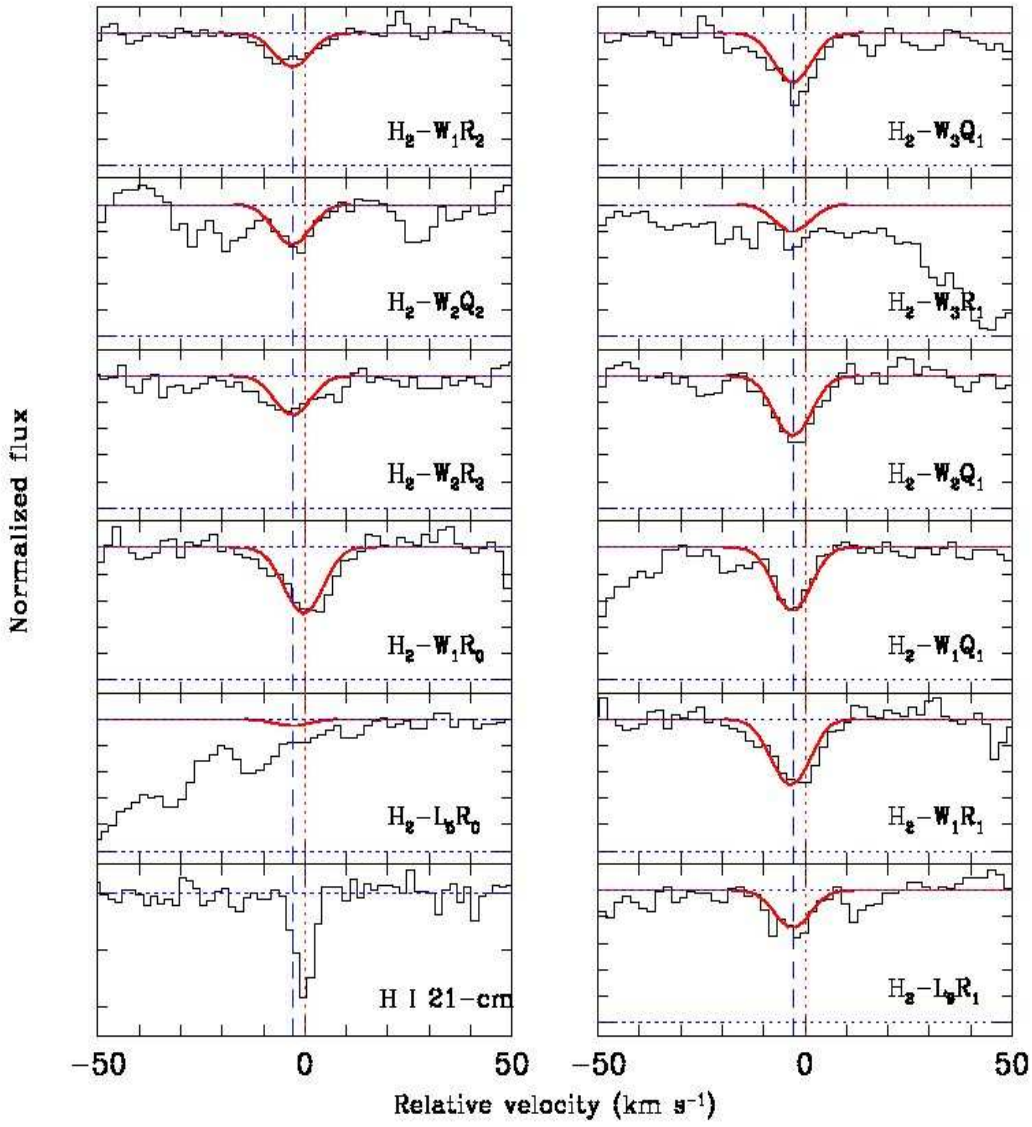
3 (sub)DLAs at the redshift of the quasar

logNH2=14 -> Few lines

$\Delta\mu/\mu < 4.0 \times 10^{-4}$

21cm and H2 are displaced by 3 km/s

⇒Systematics even in the gas at about 300 K.



$x=\alpha^2 g_p/\mu$

Srianand et al. 2010 , MNRAS, 405, 1888

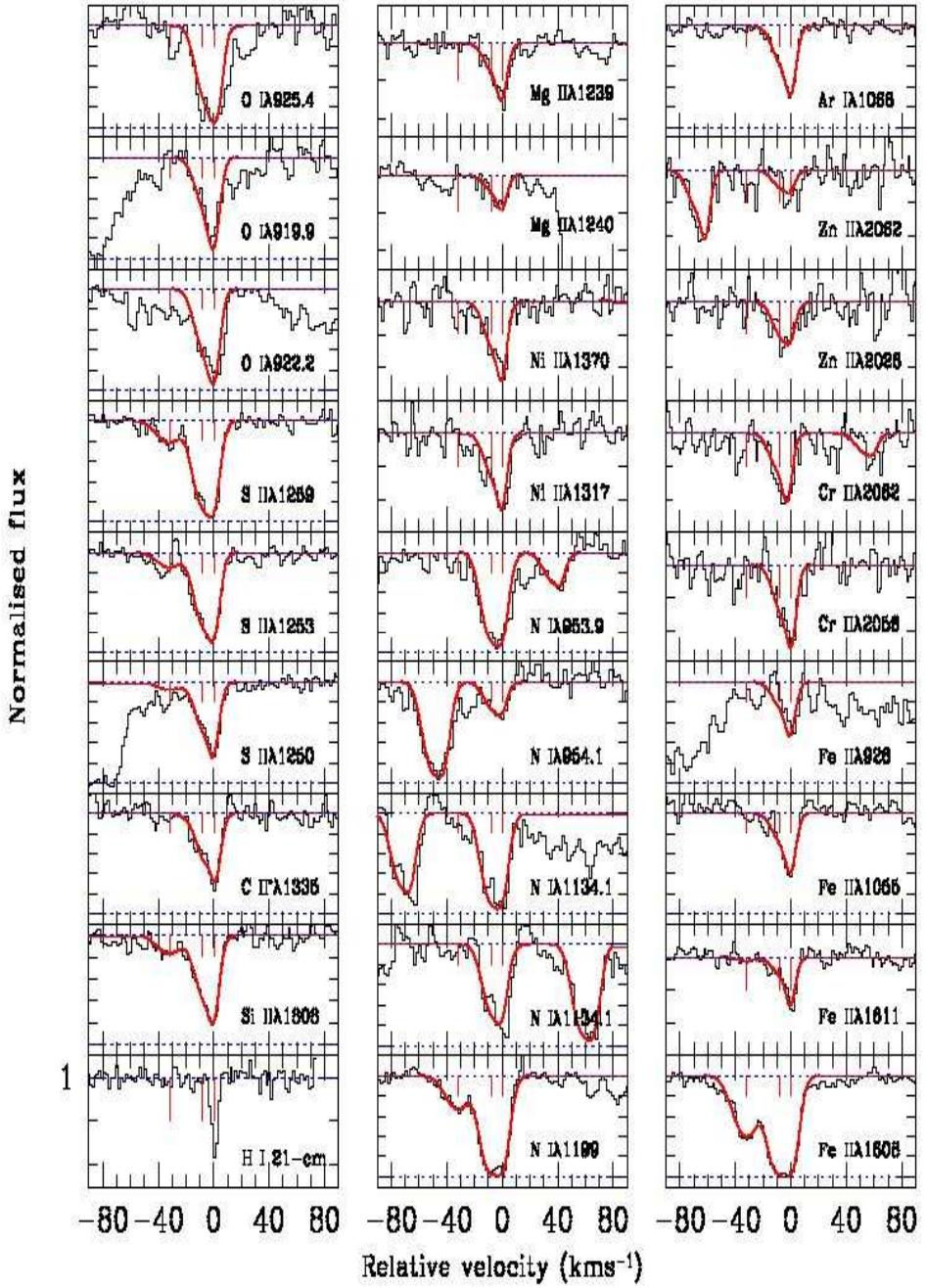
Blends : DLA

Lucky because 21cm in the wing
(even ArI is complex)

$\Delta x/x < 4.5 \times 10^{-6}$ at 3σ

$(x=\alpha^2 g_p/\mu)$

$\Delta \mu/\mu < 4.0 \times 10^{-4}$ at 3σ



Srianand et al. 2010 , MNRAS, 405, 1888

Conclusions

- 900 DLAs in SDSS
- H2 in ~10% of the systems
- Select on the basis of high metallicity, high depletion, NHI
- Once H2 is detected: Select systems with simple structure and reobserve
- Combine with HD lines

-> Future BOSS survey : 150 000 QSOs at z>2.2

- 21cm absorbers
- 2893 MgII systems with $1.15 < z < 1.45$
- Cross-correlation with NVSS and FIRST
- Flux density > 100 mJy => 36 systems: 9 detections

-> Future Askap survey

-> The ideal system: 21cm + H2+HD+UV : Q1337+3152 ... Try again !

BUT $\Delta x/x < 4.5 \times 10^{-6}$ 3σ at $z=3.17$ ($x=\alpha^2 g_p/\mu$)

=> $\Delta\alpha/\alpha < 2.2 \times 10^{-6}$ 3σ at $z=3.17$... In the North

Inconsistent with new claims

Webb et al., 2010, astroph/1008.3907

UVES data :

$z < 1.8$ $\quad -0.06 \pm 0.16 \times 10^{-5}$

$z \sim 1.5$ $\quad 0.01 \pm 0.15 \times 10^{-5}$ Srianand et al., 2007, PRL, 99, 239002

The two groups agree !

$z > 1.8$ $\quad +0.61 \pm 0.20 \times 10^{-5}$ $\quad 3\sigma$

\+ Keck $\quad -0.74 \pm 0.17 \times 10^{-5}$

Spatial Variation $\quad 4\sigma$

Systematic errors have always been underestimated

Interesting but VERY speculative (see title)