The ISM at High Redshift

-> 21cm absorbers at z~1.5

-> Molecular Hydrogen in DLA systems

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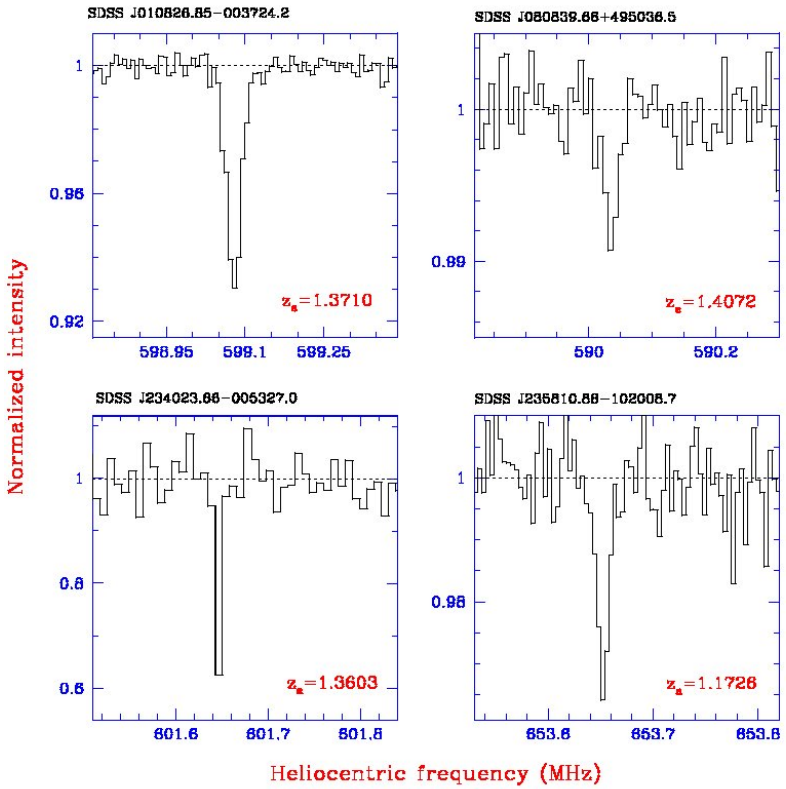
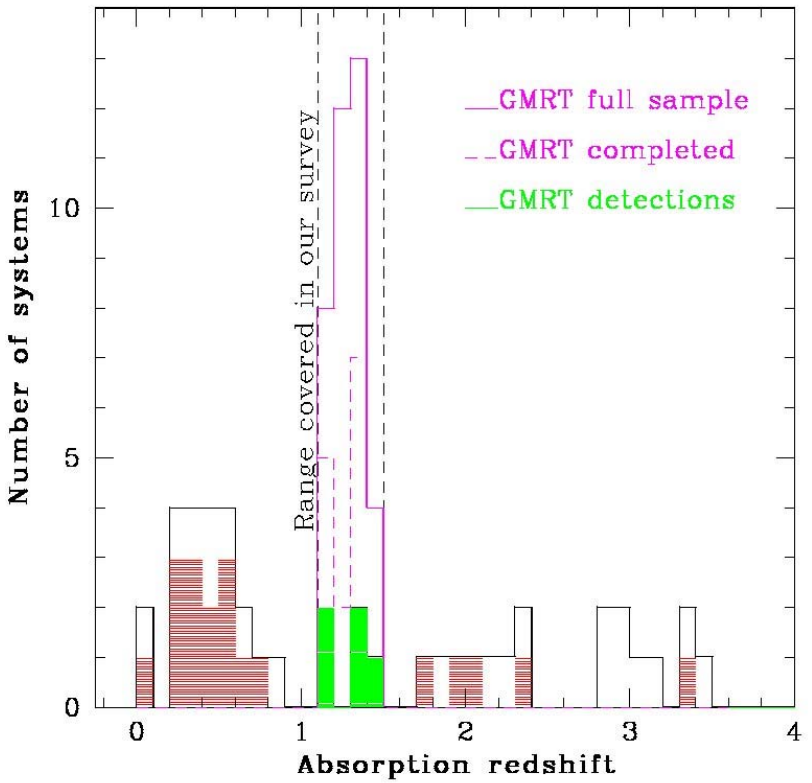
21cm absorption at z~1.5

- From the 21cm optical depth -> N(HI) x fc / Ts
- N(HI) from Lyman-α absorption
- Covering factor -> Structure of the absorber
- Spin temperature : physical conditions in the gas
- DLAs: 17 detections (none between z=1-1.5)

- Instead of DLAs we search for MgII systems with wr>1A (Turnshek and Rao) -> Confirmation to come with COS
- 2893 MgII systems with $1.15 < z < 1.45$
- Cross-correlation with NVSS and FIRST
- Flux density > 100 mJy => 36 systems
- 290 hrs of GMRT; half completed

SDSS-GMRT Sample of MgII Systems



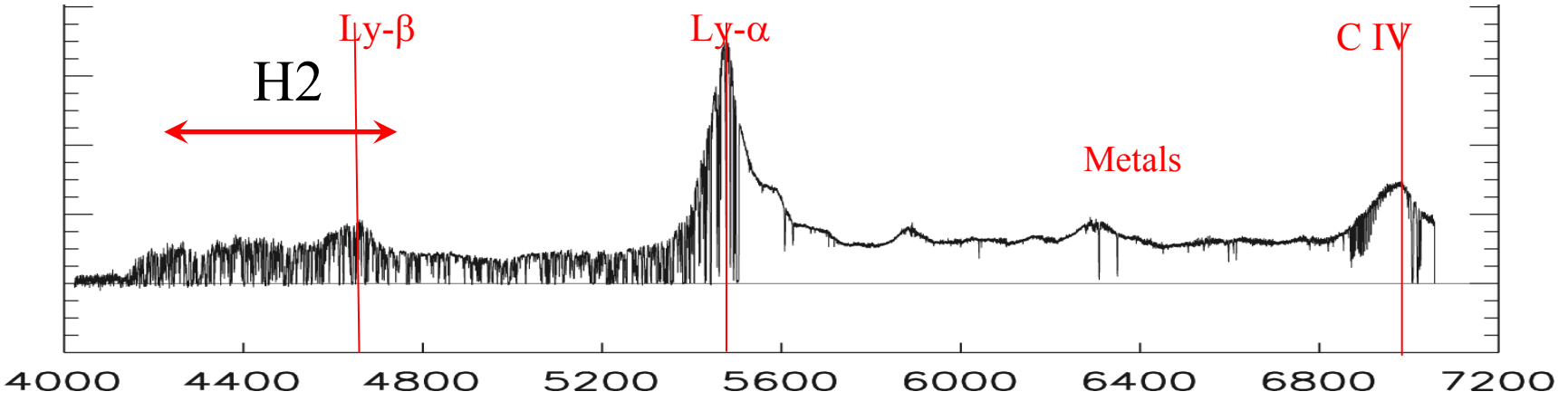


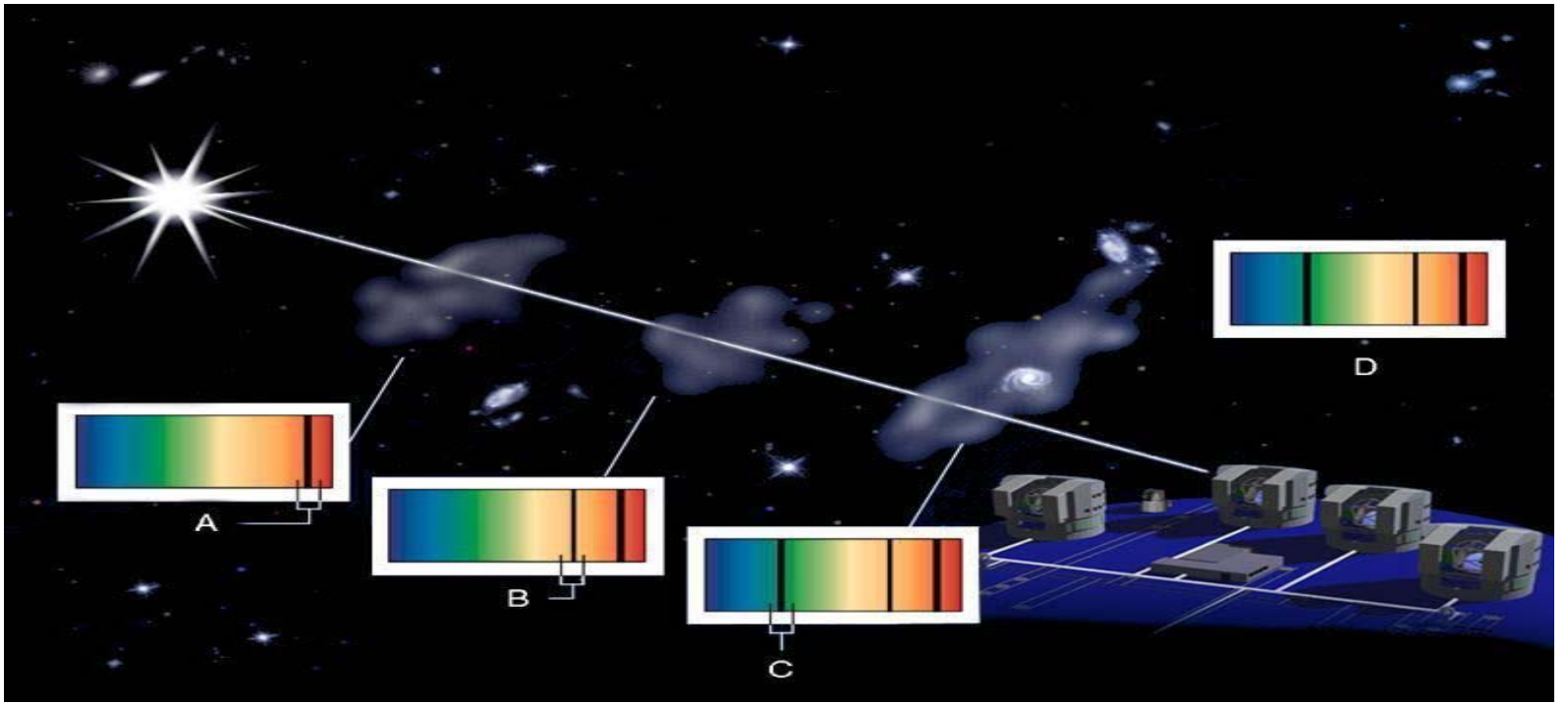
5 detections out of 18 systems -> 10 expected

Physical conditions of the gas + variation of constants

Gupta et al. (2007), ApJL, 654, L111

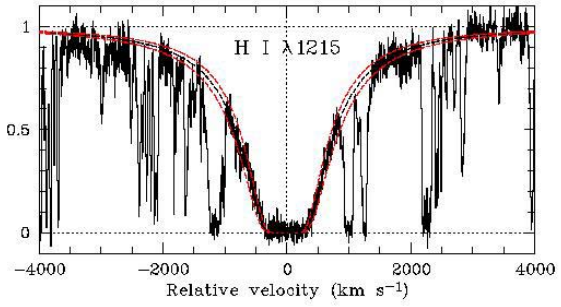
H2 in Quasar Absorption Lines -> High SNR and High Resolution data : UVES-VLT





Damped Ly-α Systems

HI :



Metals :

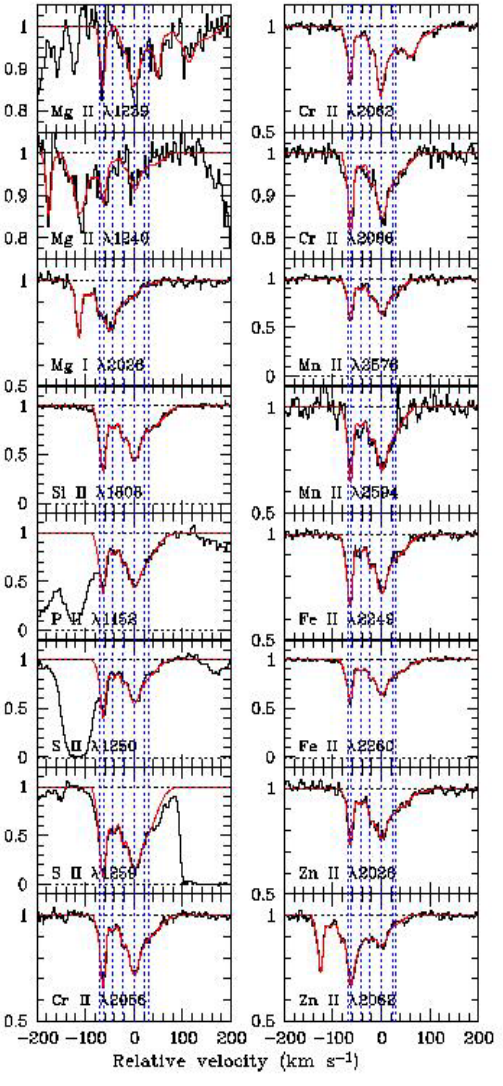
-> Metallicities

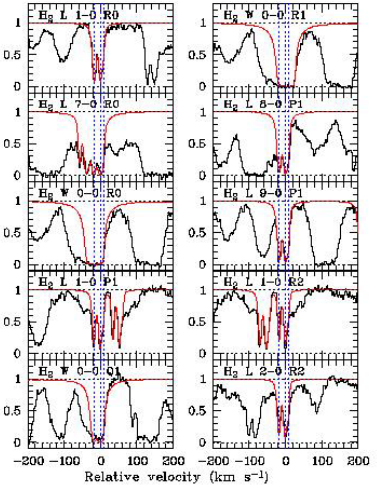
-> Dust content

-> Kinematics

Star- Formation ?

Winds ?





Molecules H2 + CI, CI* :

-> Density/Temperature

-> UV flux (excitation)

Why H2 ?

- First molecule to be formed
- Important coolant in the metal free gas
- H2 is ubiquitous in star-forming giant clouds and in the diffuse interstellar medium in our Galaxy

- H2 is formed on the surface of dust-grains :What is the role of dust ?
- Excitation of H2 in different rotational levels: Signature of the UV ambient flux + Physical properties of the gas
- Other molecules ? CO, HD
- By-products: variation of $\mu=me/mp$

UVES survey

67 DLAs – sub.DLAs

Spectral resolution R=43000; SNR>20 per pixel

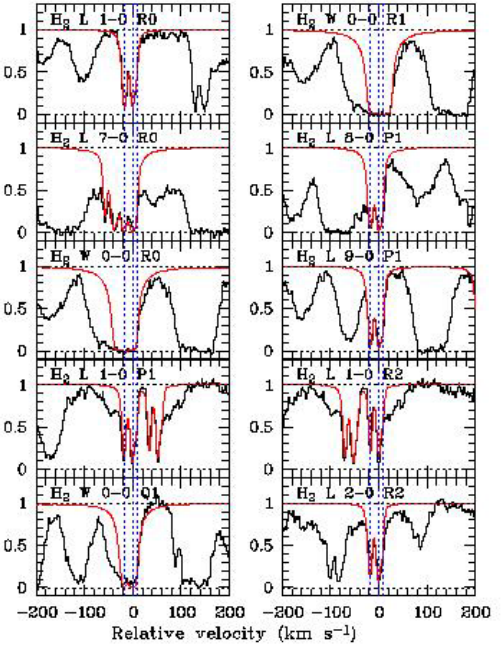
H2 detected in 14 systems (15-20%)

Non detection :

$f = 2xN(H2)/(2xN(H2)+N(HI)) < 10^{-5} - 10^{-7}$

Detection threshold ~10^{14} cm^{-2} : 3h exposure time per spectrum for no detection

-> 8h in case of detection.



Highest redshift

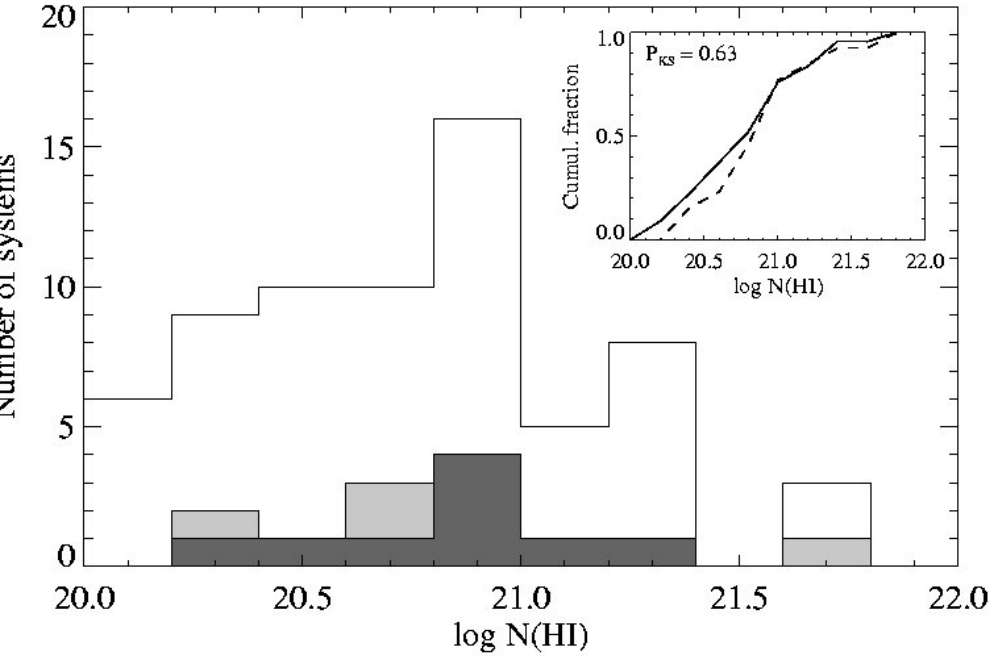
J1443+2724 z = 4.224

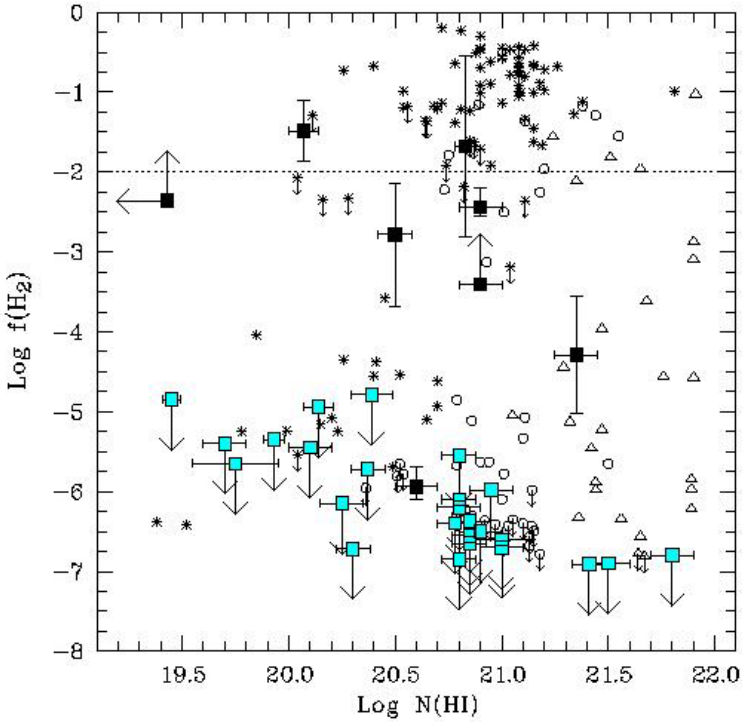
Petitjean et al. (2000), A&A, 364, L26

Ledoux et al. (2003), MNRAS, 346, 209

Noterdaeme et al. (in preparation)

HI Column density



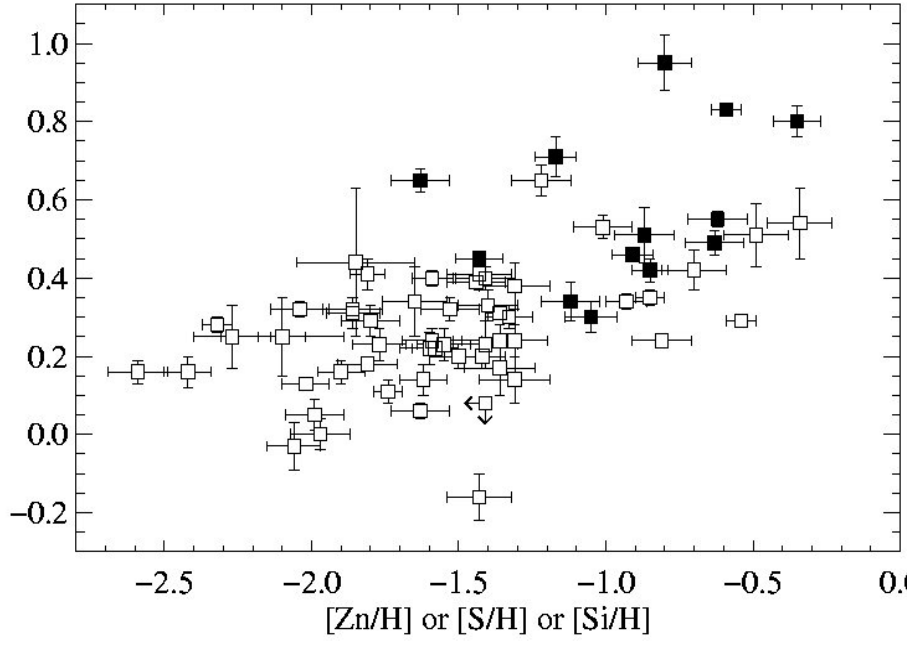


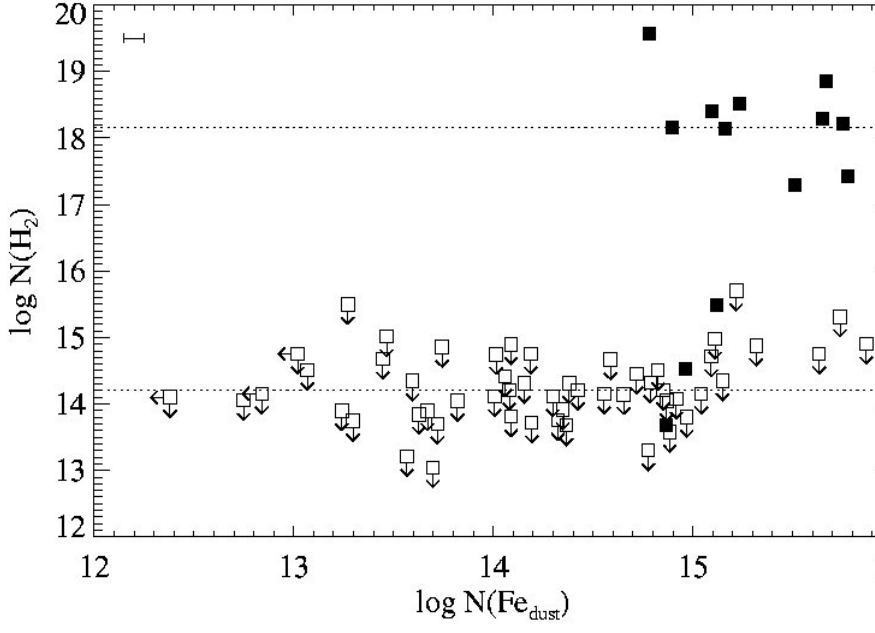
-Presence of H2 is independent of N(HI)

- Molecular fraction, f, smaller than in the Galactic disk

  - > Magellanic clouds or halo diffuse clouds

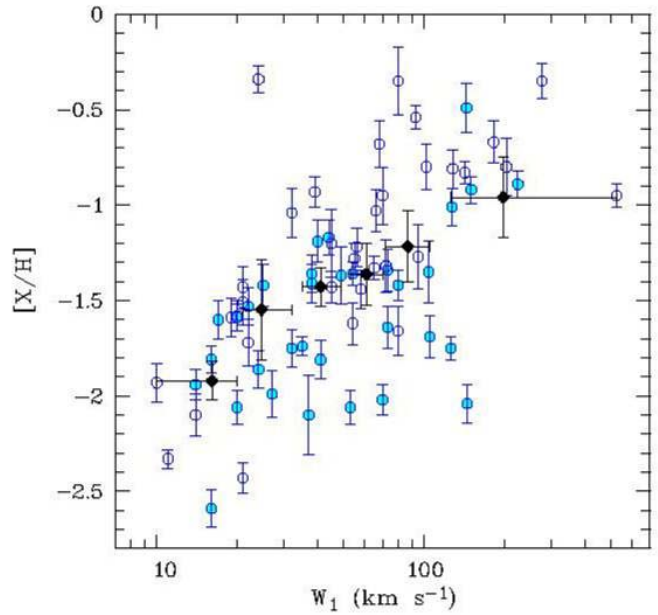
Presence of dust

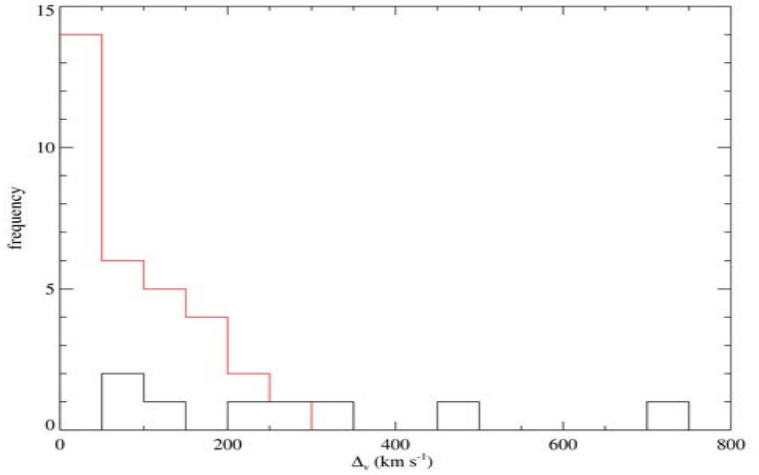




- Correlation Depletion ([Zn/Fe]) vs Metallicity ([Zn/H])
- Presence of H2 related to the dust column density

Mass-Metallicity Relation ?



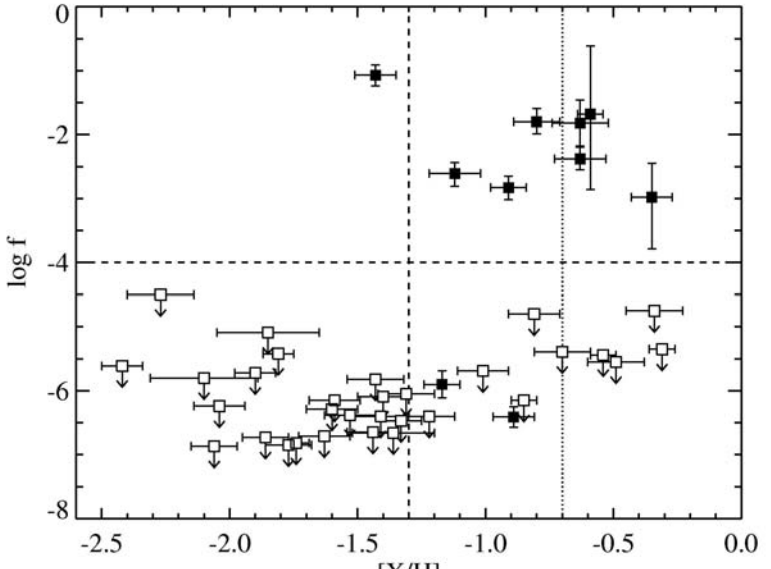


X/H] : metallicity - W1 : Absorption Width

Presence of H2 for High metallicities

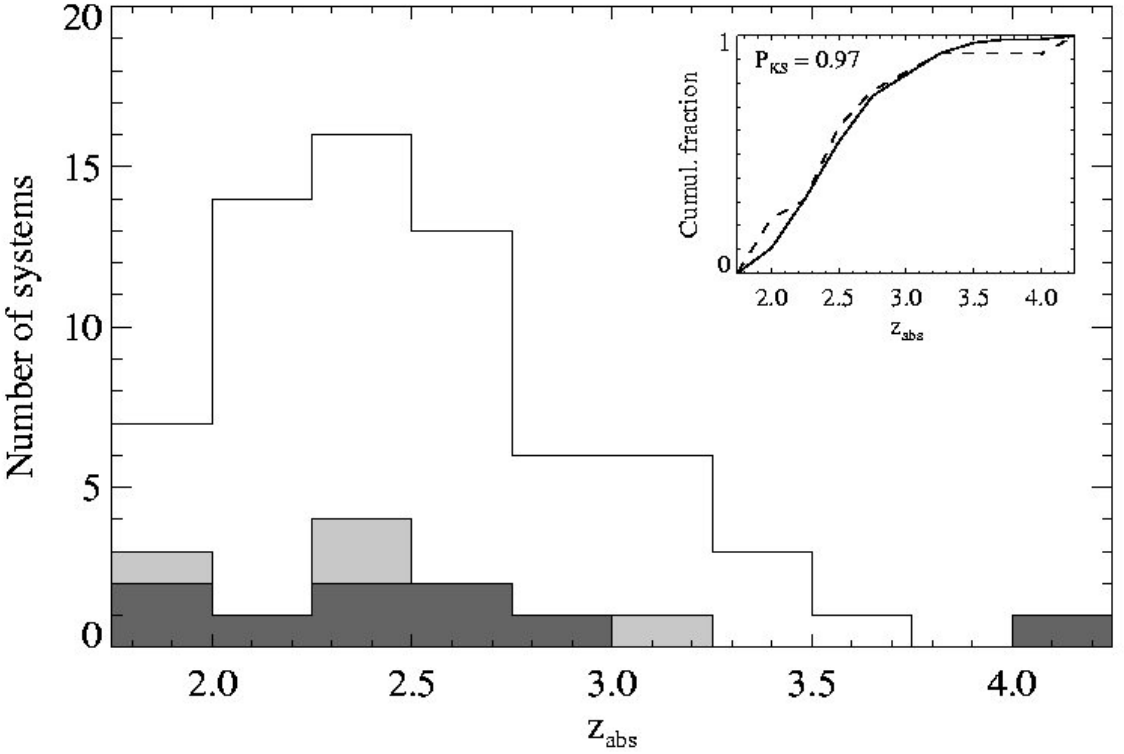
AND high velocity width

Metal Rich = Massive Galaxy ?



adaux et al., 2006, A&A, 457, 71

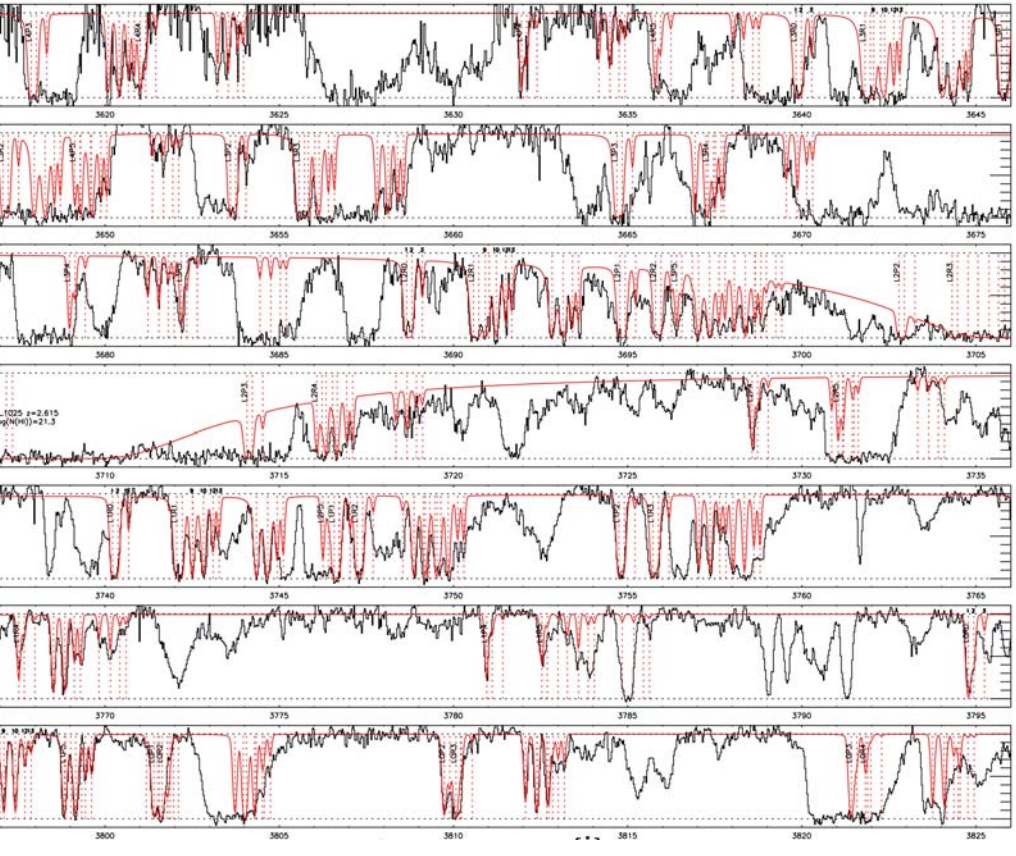
No redshift evolution

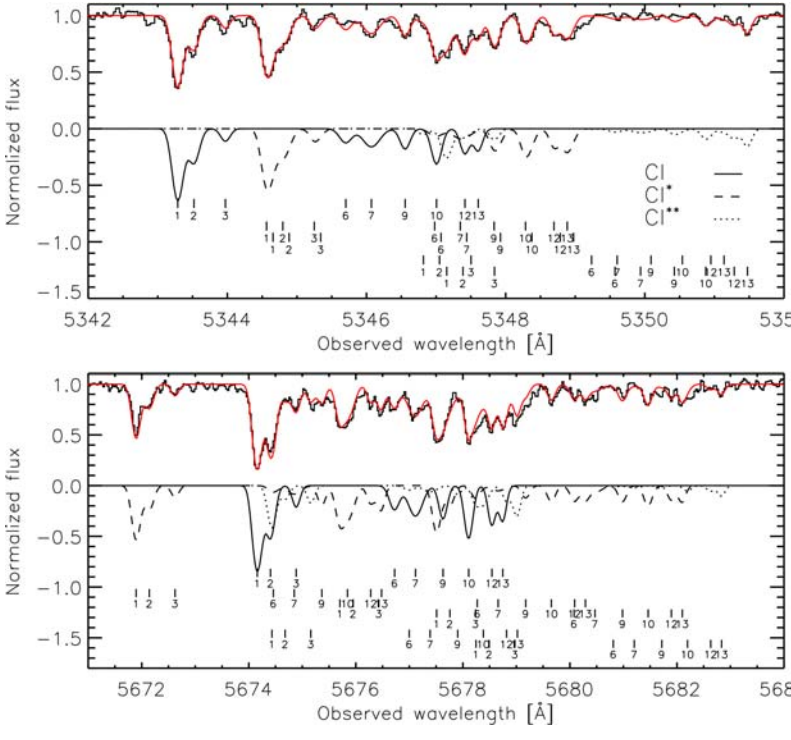


Physical conditions : Q2348-022 z=2.4263

13 metal line components and 7 H2 components in the same system
-> study of the ISM of a remote galaxy

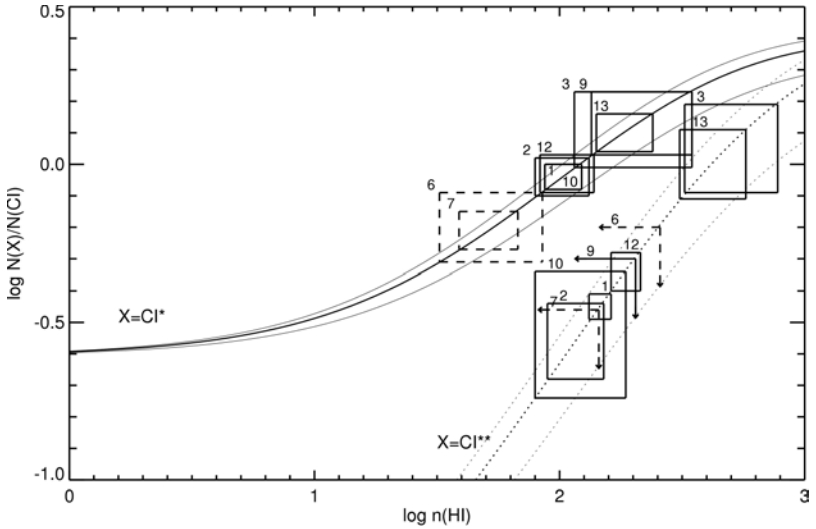
* Deblending and complex fitting

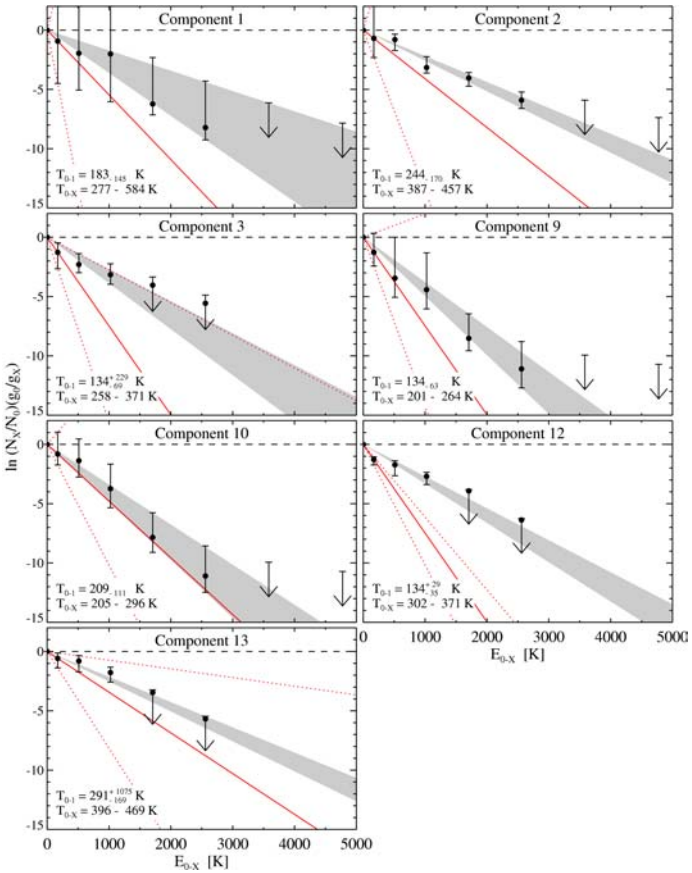




H2 and CI-CI*-CI**

Physical conditions : Q2348-022 z=2.4263





Tkin ~ 150 K

Particle density : 10 - 100 cm-3

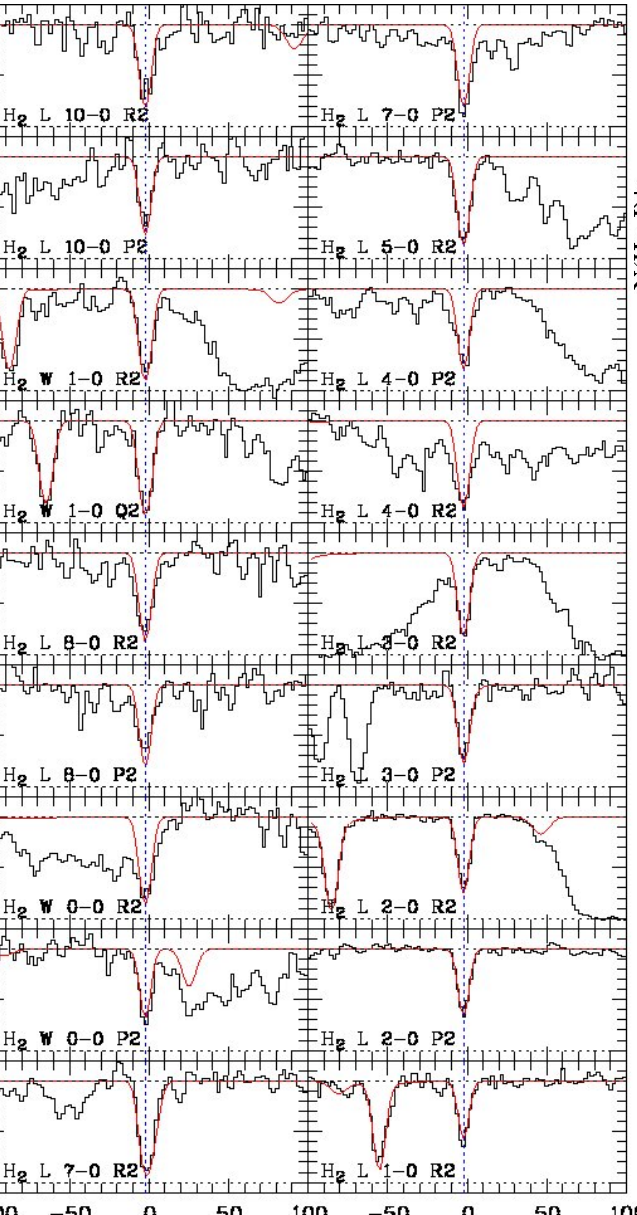
Excitation temperature : 300 K or larger

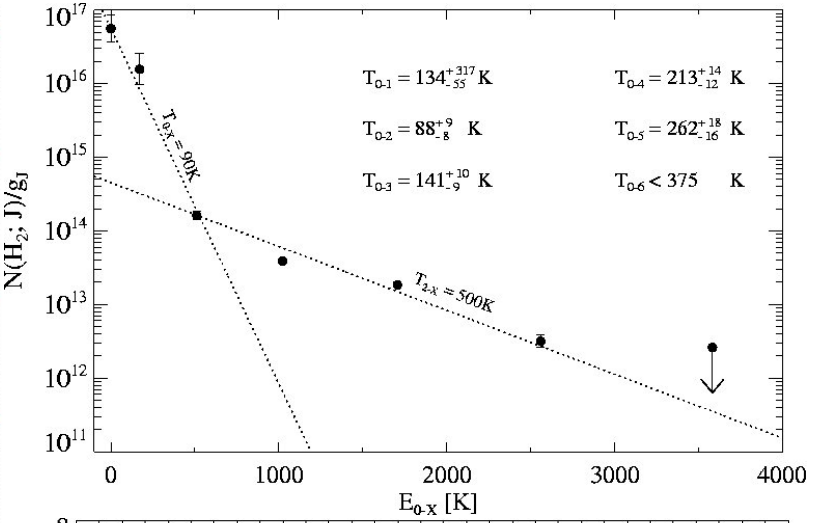
-> Same problems as in the galactic ISM

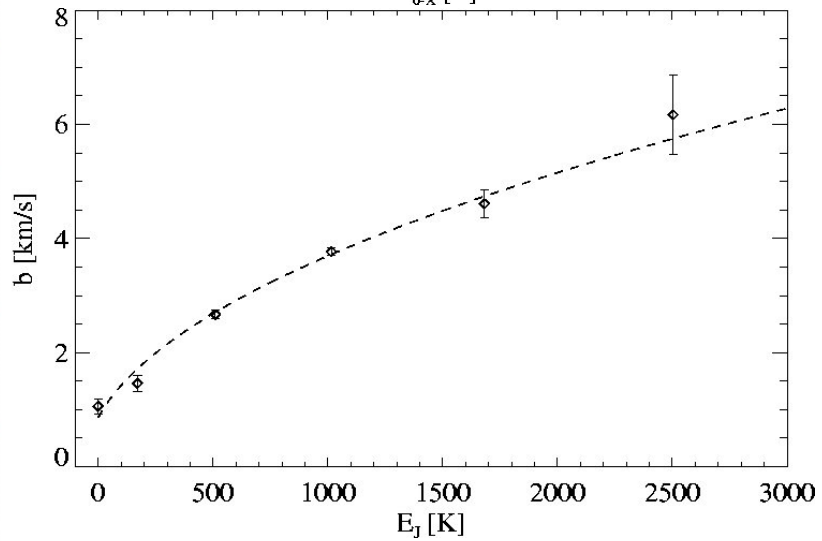
-> UV flux from 1 to 20 times that in our Galaxy

Noterdaeme et al. (2007), astro-ph/0703218

Heating processes







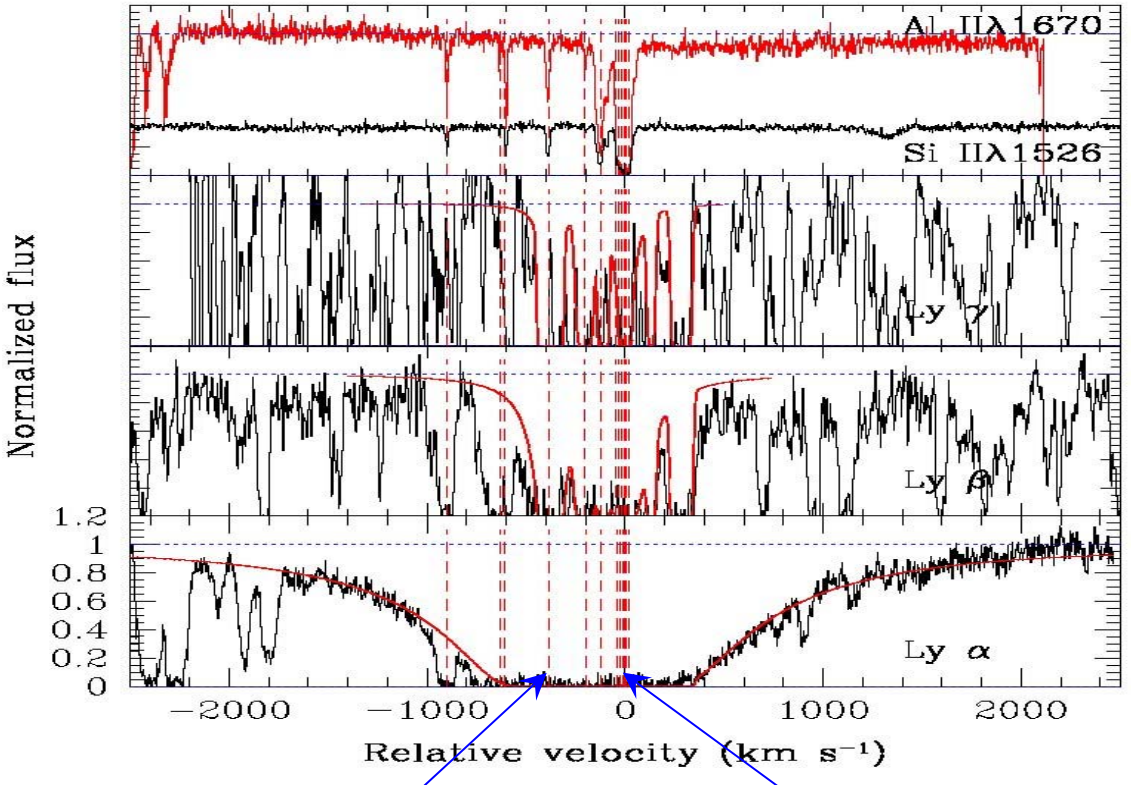
2 components ?

No shift – Ad'ho

⇒New Heating Process

Doppler parameter increases with J

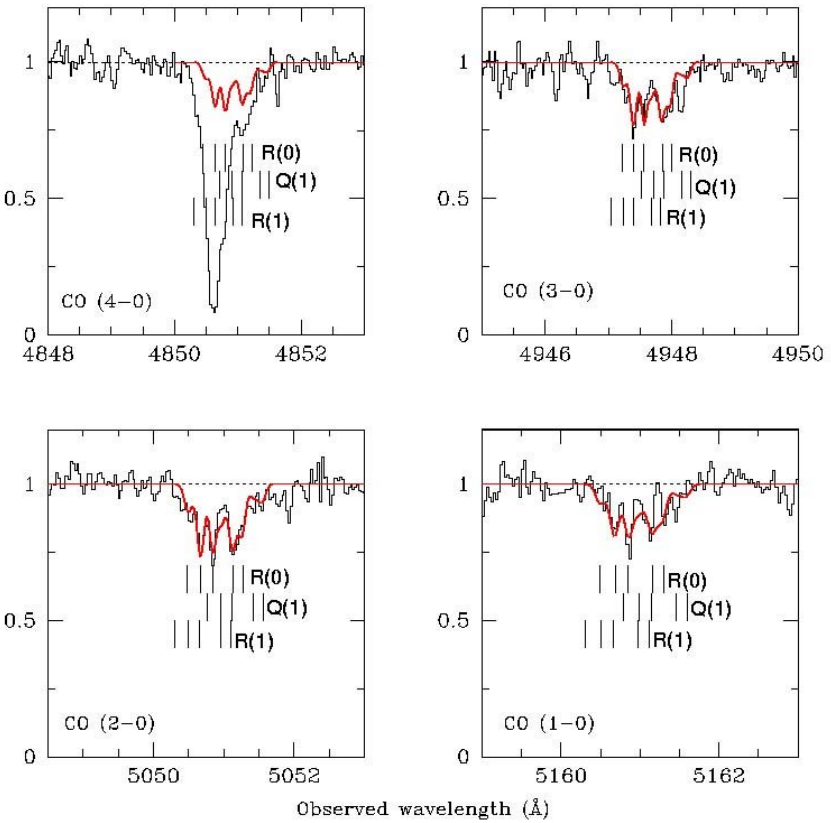
Other Molecules

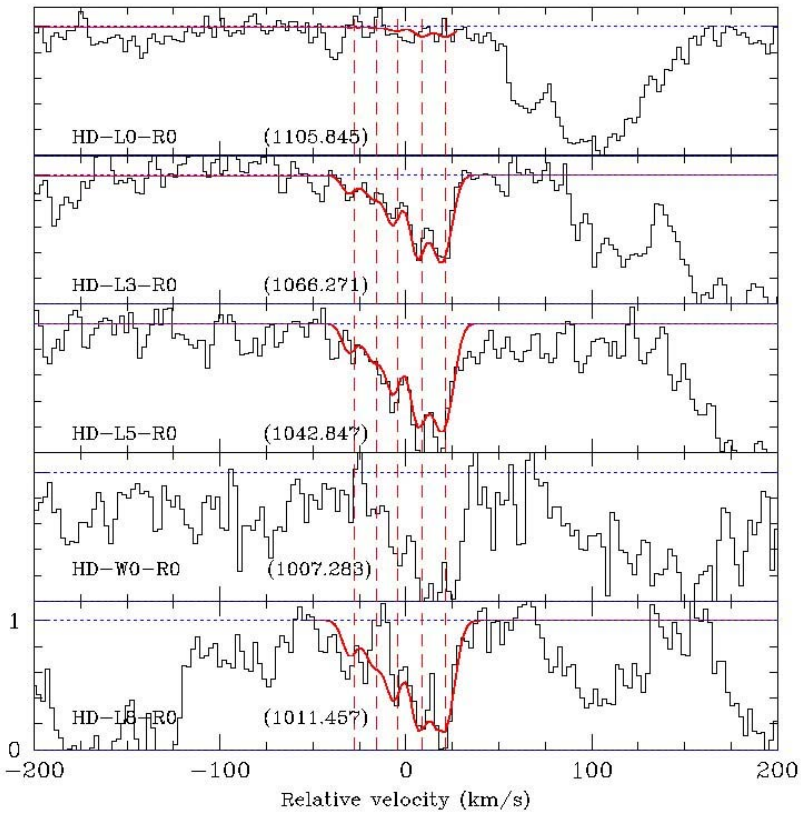


19.8 Log N(HI) 20.1

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

CO and HD

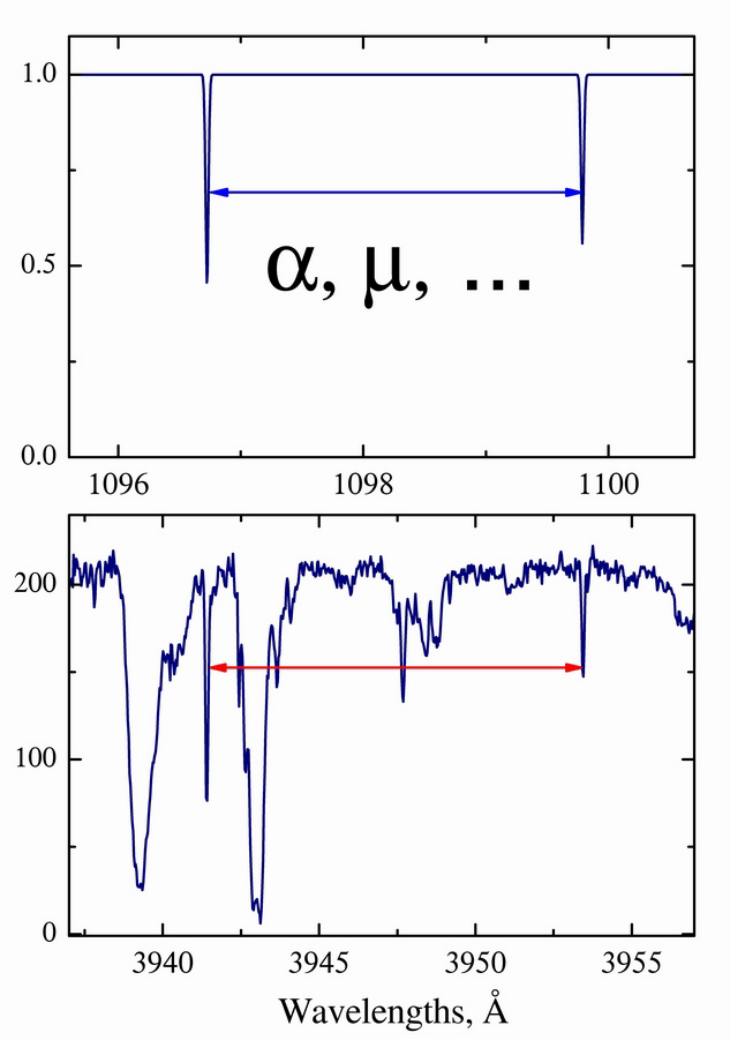




Log(f) = -0.3 (highest in DLAs) ; CO/H2 = 3×10^{-6}

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

Variation of $\mu = m_p/m_e$

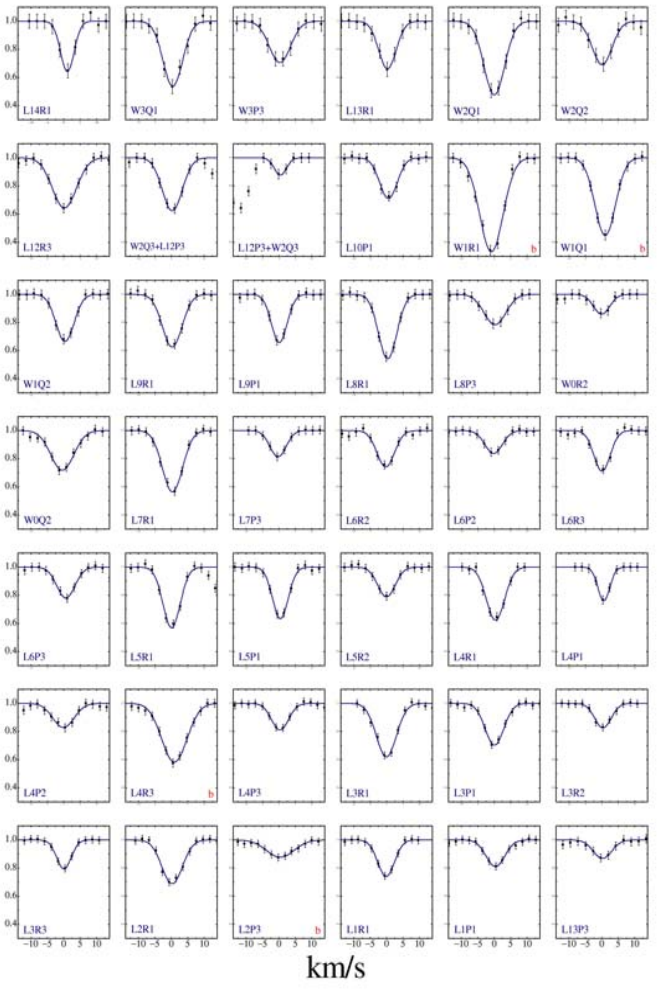


$$\frac{\lambda_i^{obs}}{\lambda_i^{lab}} = (1 + z_{abs})\left(1 + K_i \frac{\Delta\mu}{\mu}\right)$$

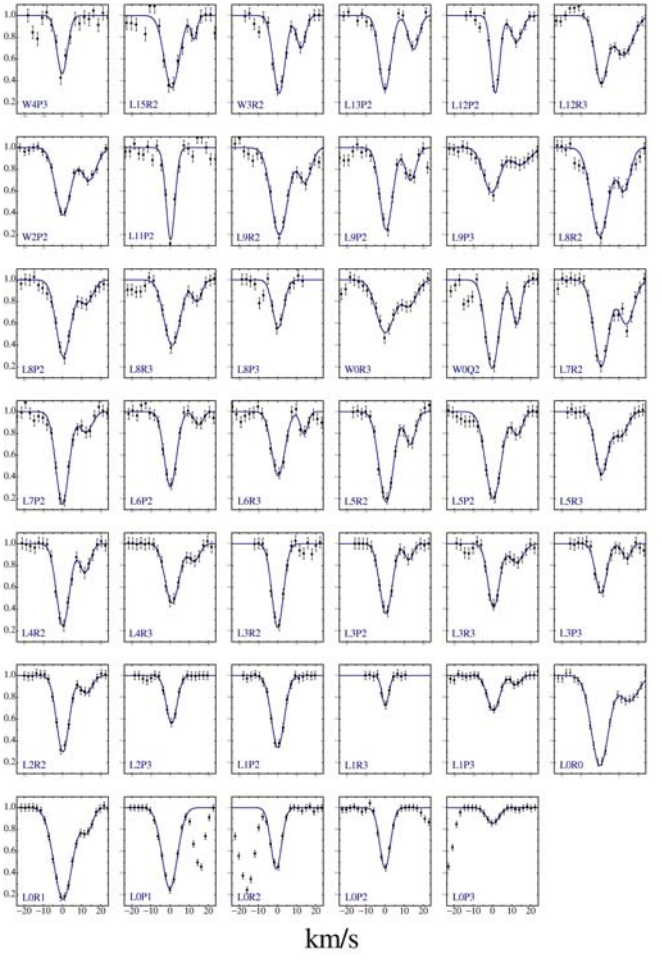
$$\lambda_i^{obs}, \quad \lambda_i^{lab}, \quad K_i$$

Best data up to now

Q0347-383



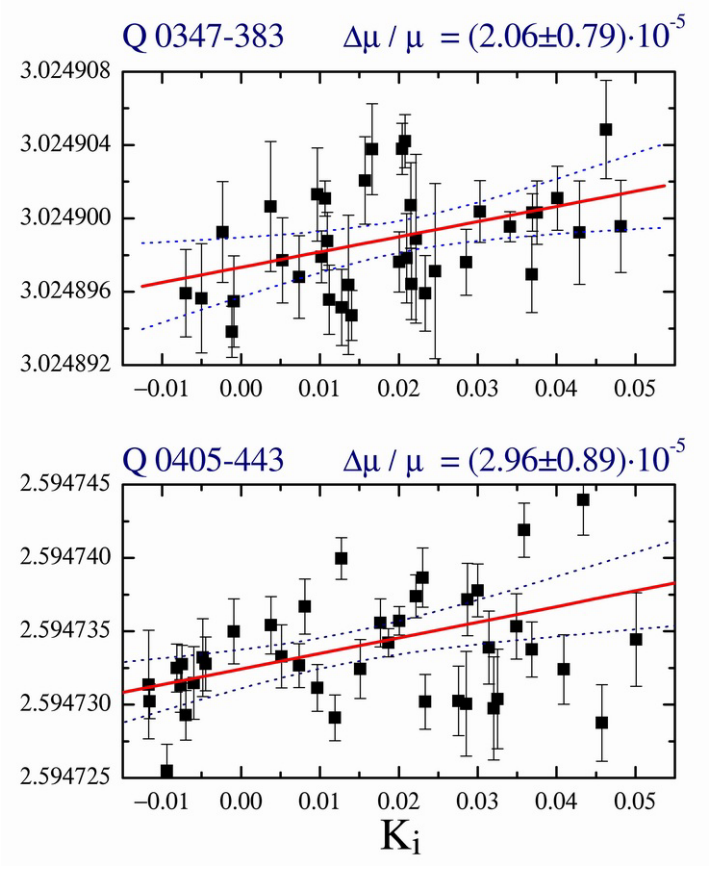
Q0405-443

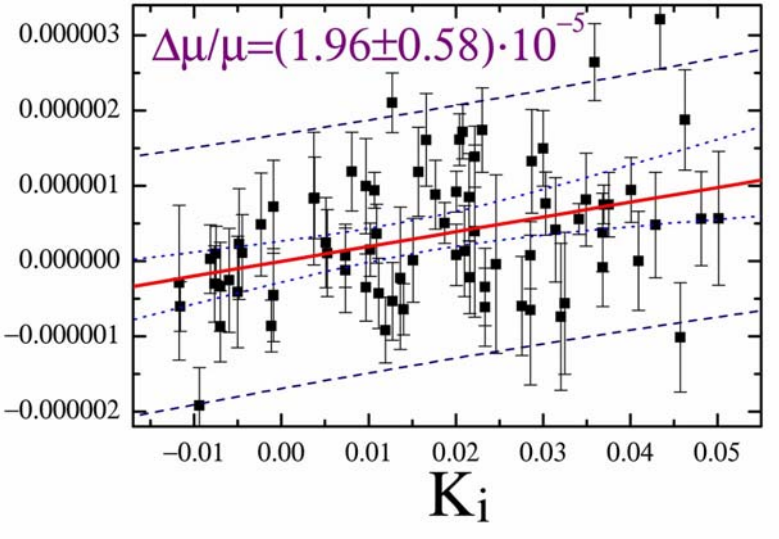


UVES: 20 hours per line of sight – Only two cases

High Resolution : Blending - Narrow lines

Results





- More laboratory wavelengths
- Increase the number of lines of sight WITH the same lines
- -> Need for ELT : SNR

Conclusions

- Ongoing GMRT survey for 21cm absorber at z~1.5;
  5 detections out of 18 strong MgII systems up to now

- UVES-VLT survey for molecular hydrogen in DLAs
- 67 systems and 14 detections
- No dependence on N(HI)
- Detections at high metallicity and high depletion factor
- T~150 K ; n=10-100 cm^{-3} ; UV flux 1 to 20 times Galactic
- CO detected for the first time ; HD detected in 2 systems

- If CODEX then need for a survey of DLAs at z>3
- VLT should be dedicated to the UV