Constraining the intergalactic UV background with metal line systems

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QSO absorption lines

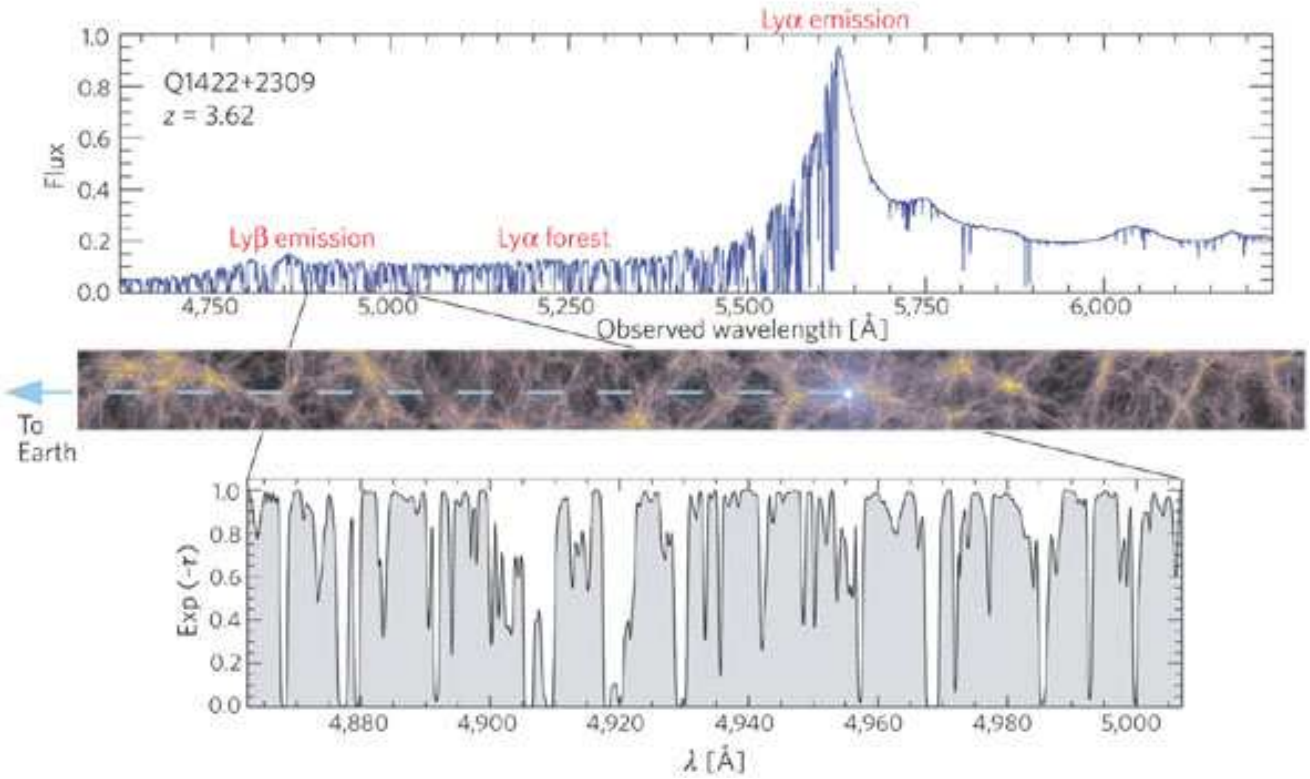


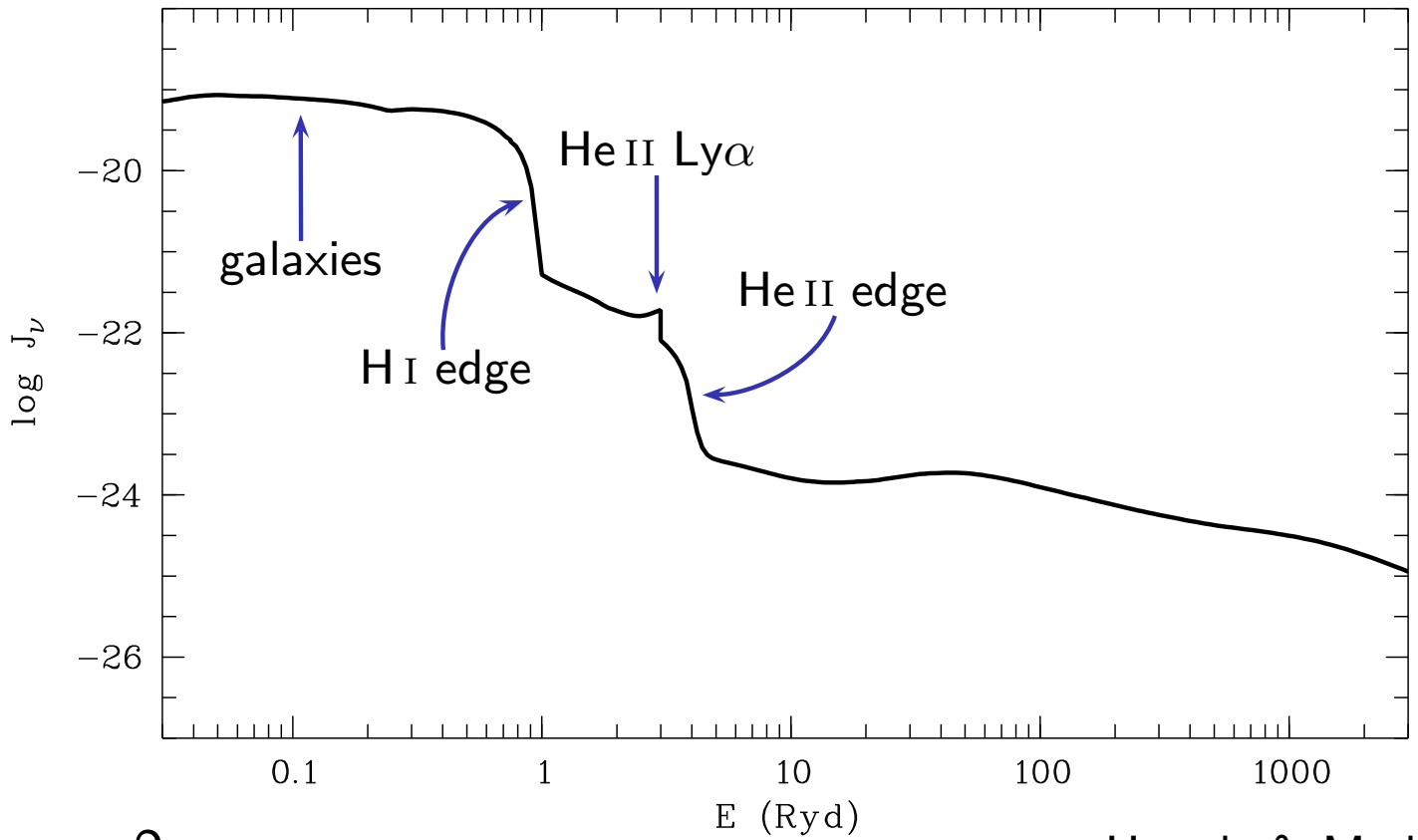
Figure from Springel et al. (2006)

IGM is highly photoionized: $n_{\mathrm{H\,I}}/n_{\mathrm{H}} \sim 10^{-4}$

$\Rightarrow$ ionization corrections required (e.g. for metallicity estimates)

Spectral energy distribution

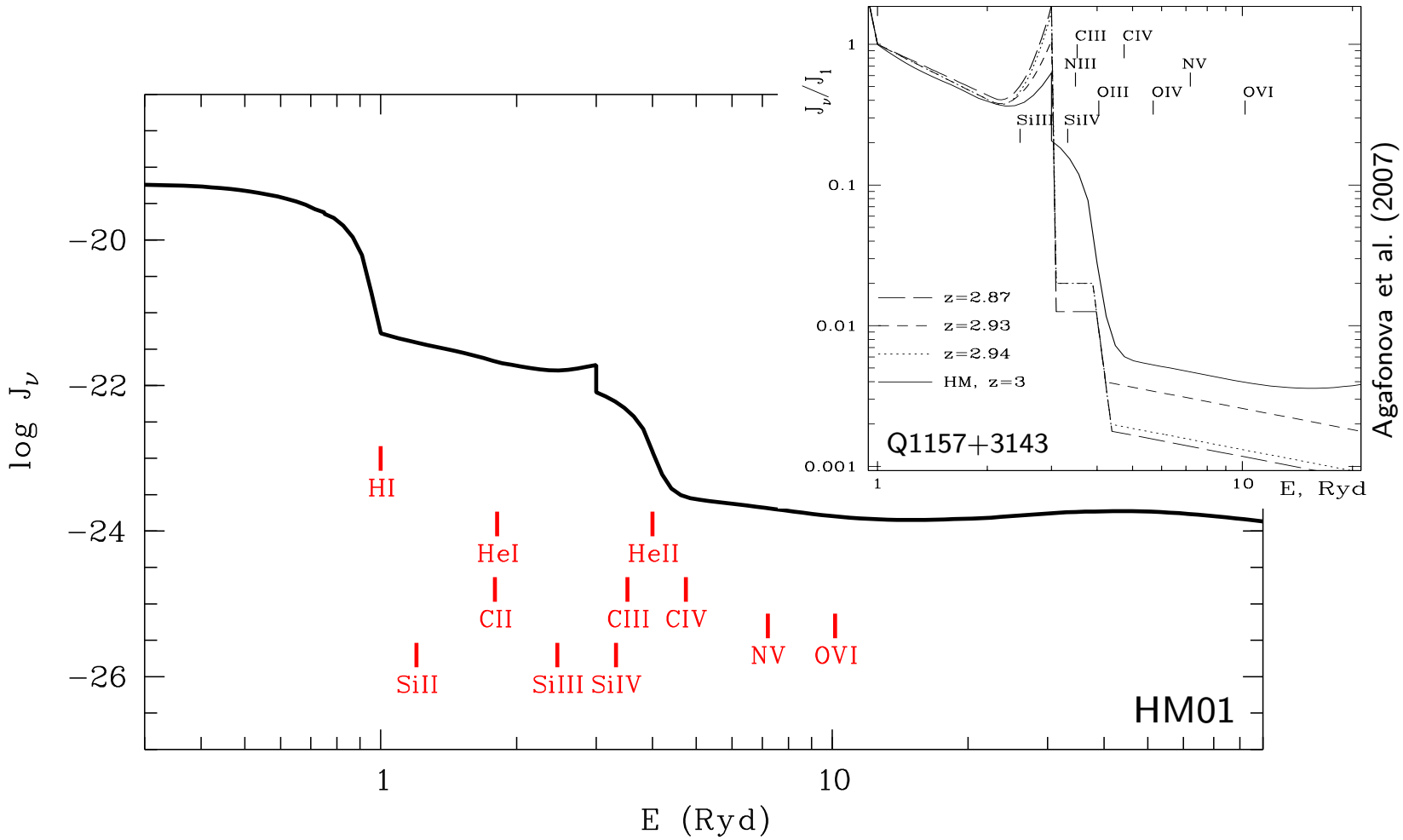
radiation of quasars and galaxies filtered while propagating through the IGM



$z \approx 2$

Haardt & Madau (2001)

Metal line systems and the shape of the UV background



Deviations from HM01 are detected in several metal line systems!

Photoionization modeling of metal line systems

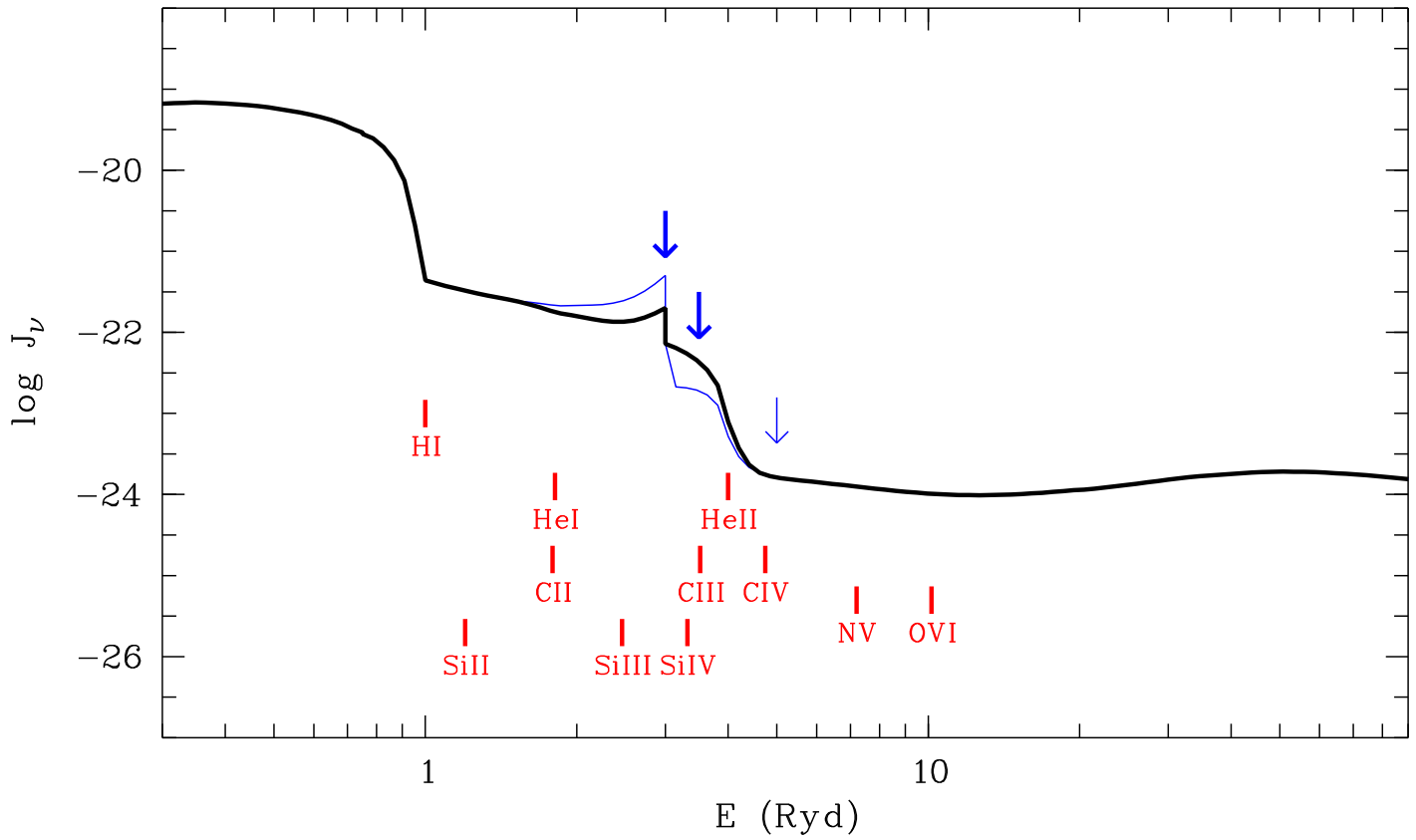
. . . with CLOUDY (Ferland et al. 1998)

- adopt spectral energy distribution of the UV background
- find ionization parameter (i.e. density) to match an observed column density ratio
- scale metallicity (and relative abundances) to match the observed column densities

If two or more ratios are available, it is possible to . . .

- . . . estimate which spectral energy distribution is consistent with the data.
- . . . investigate the uncertainty of the model parameters with respect to the shape of the ionizing radiation.

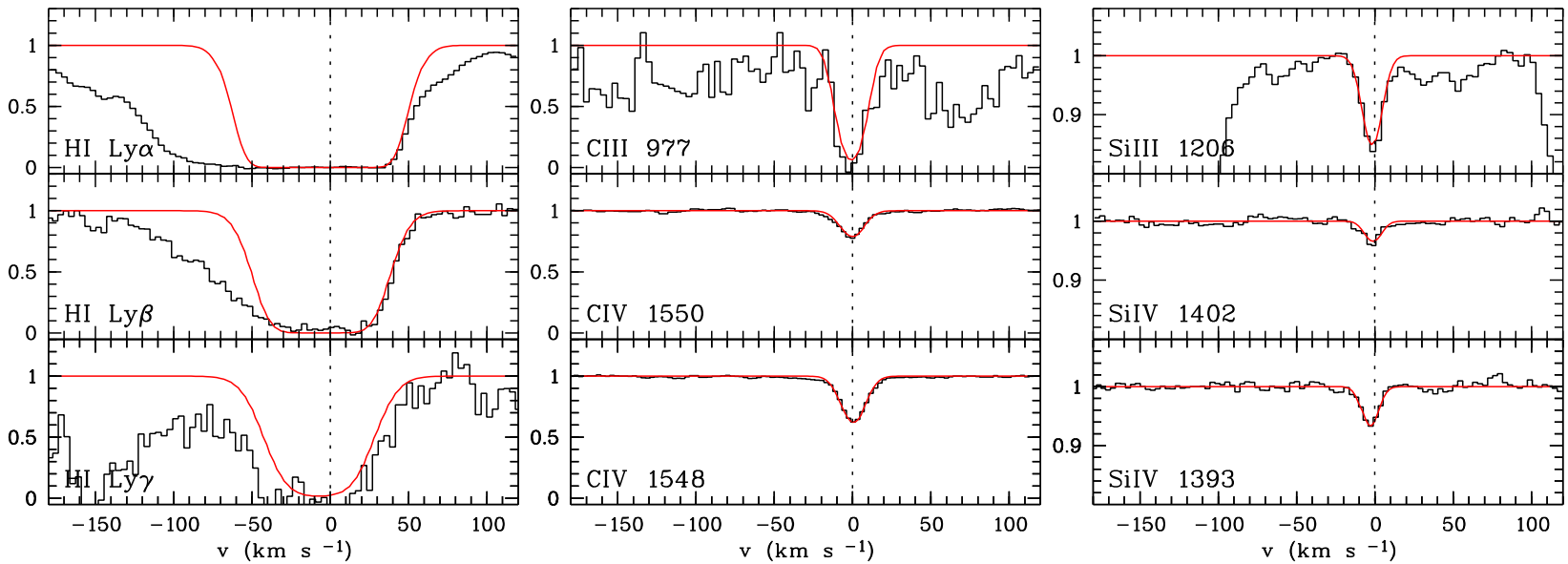
Variation of the UV background spectrum



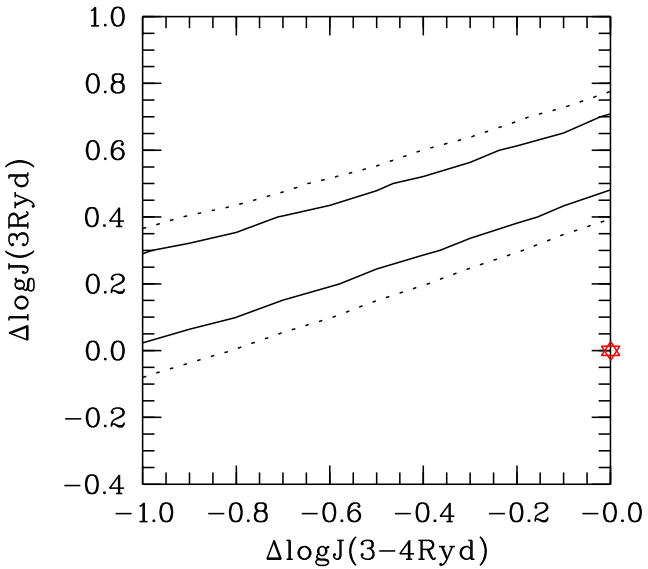
change height of 3 Ryd peak and flux between 3 and 4 Ryd

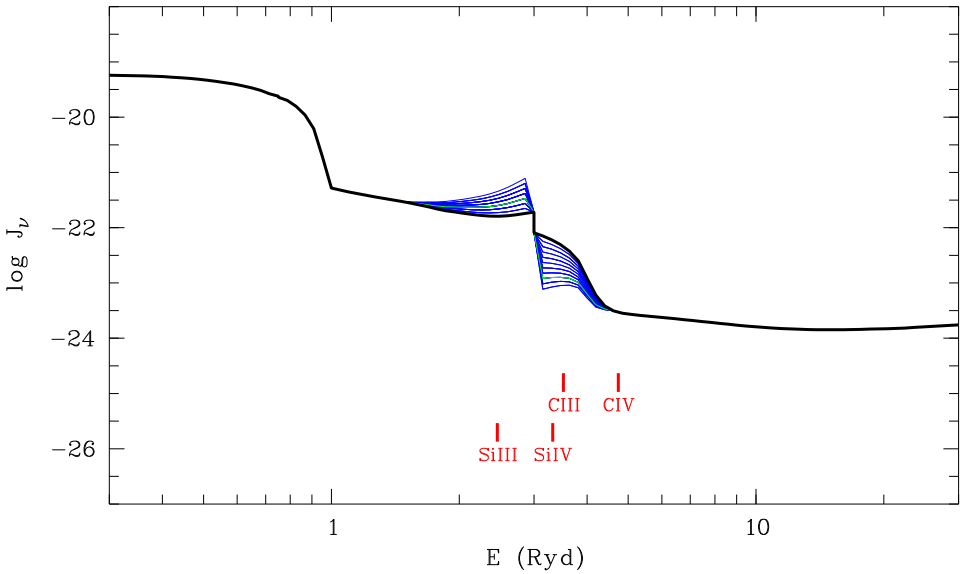
Test study with optical data – HS1700+6416

System at $z = 2.3799$ towards HS1700+6416 (Keck data)



The UV background at $z = 2.38$ towards HS1700+6416





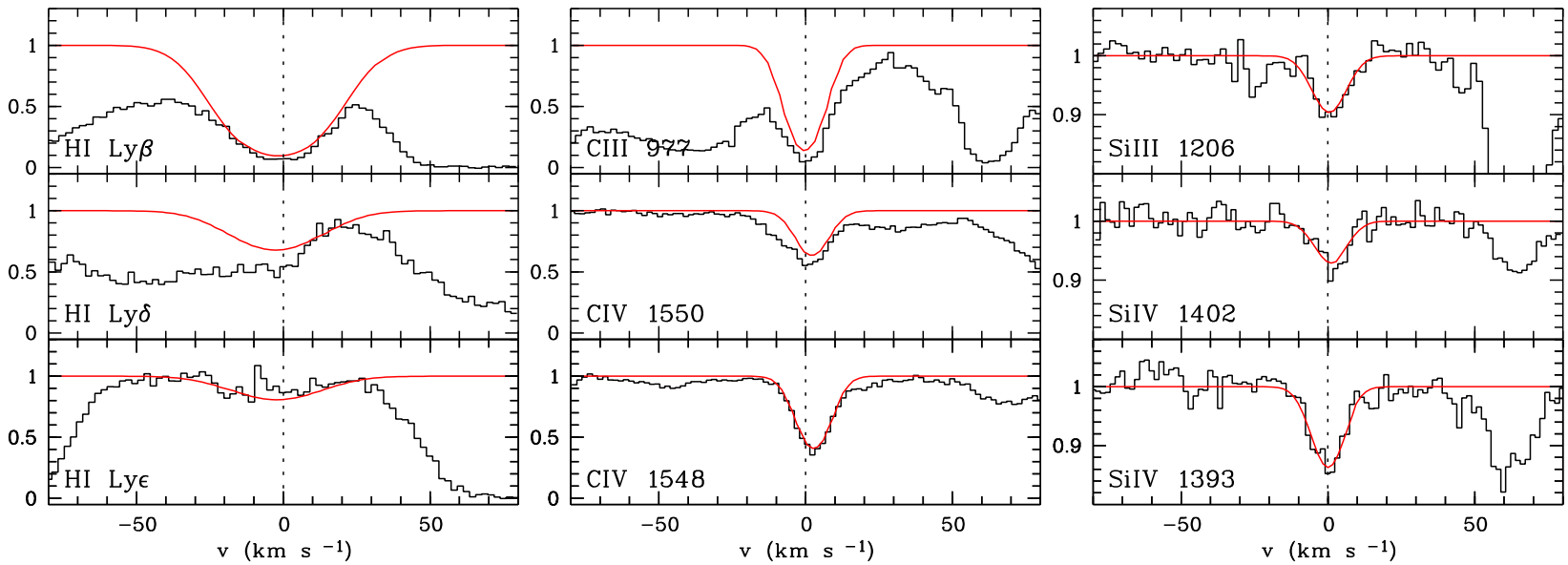
$$\log U = -1.59 \pm 0.15$$

$$[\mathrm{Si/H}] = -2.22 \pm 0.07$$

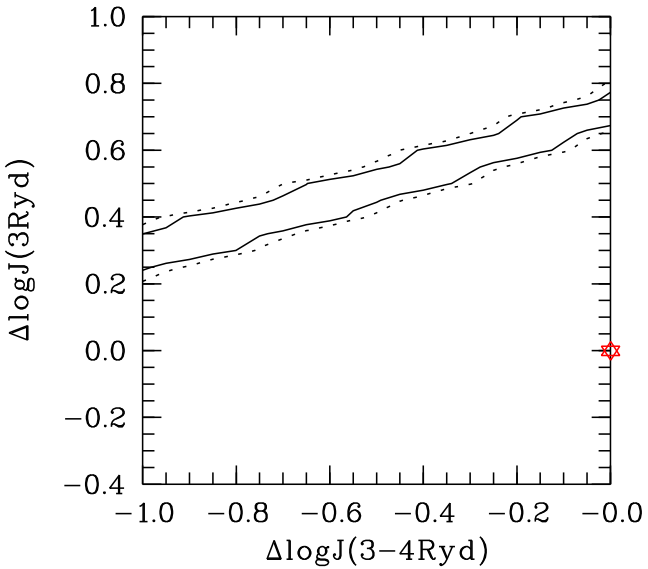
$$[\mathrm{Si/C}] = -0.25 \pm 0.24$$

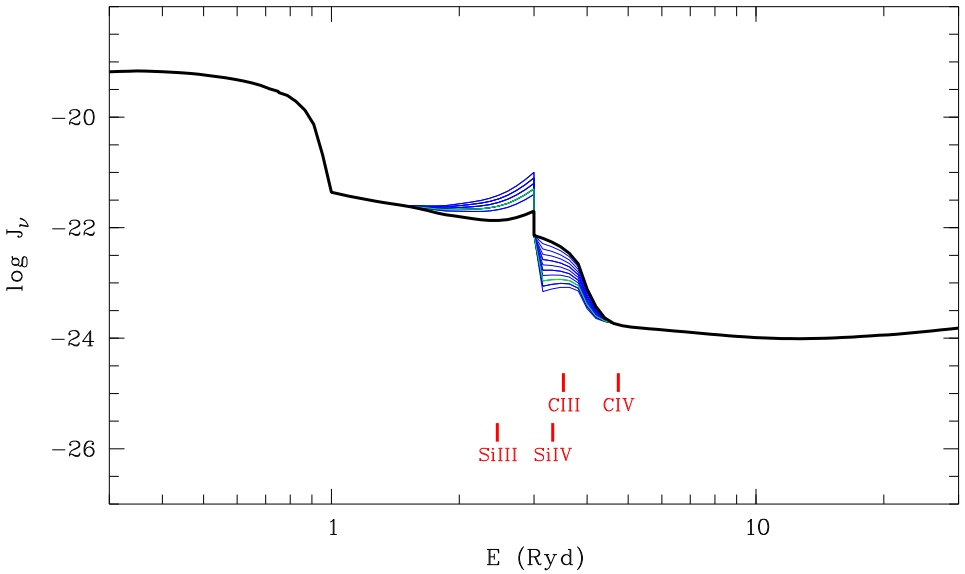
Test study with optical data – HE0940-1050

System at $z = 2.8266$ towards HE0940-1050 (UVES data)



The UV background at $z = 2.83$ towards HE0940-1050





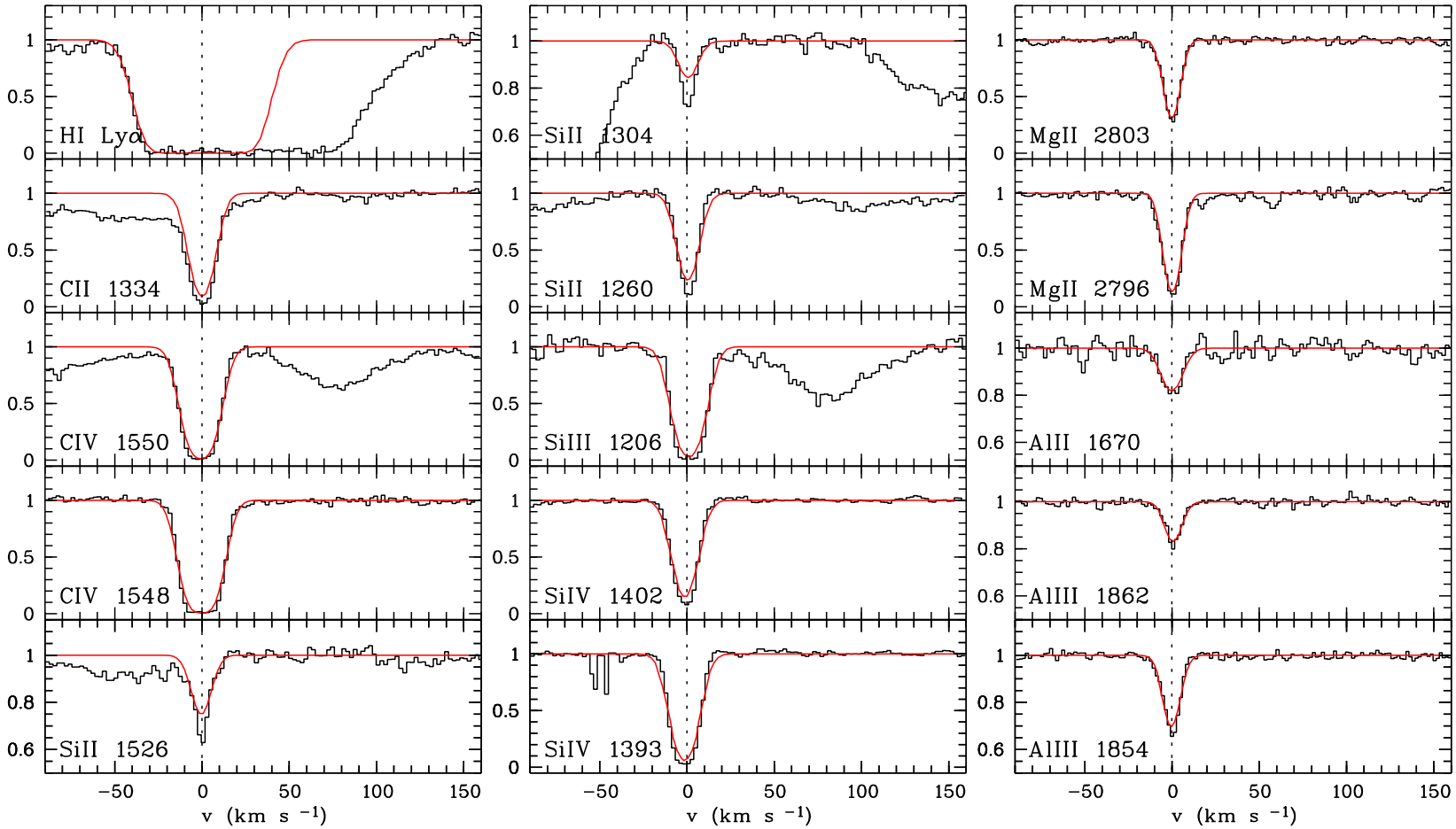
$$\log U = -1.10 \pm 0.10$$

$$[\mathrm{Si/H}] = -1.06 \pm 0.15$$

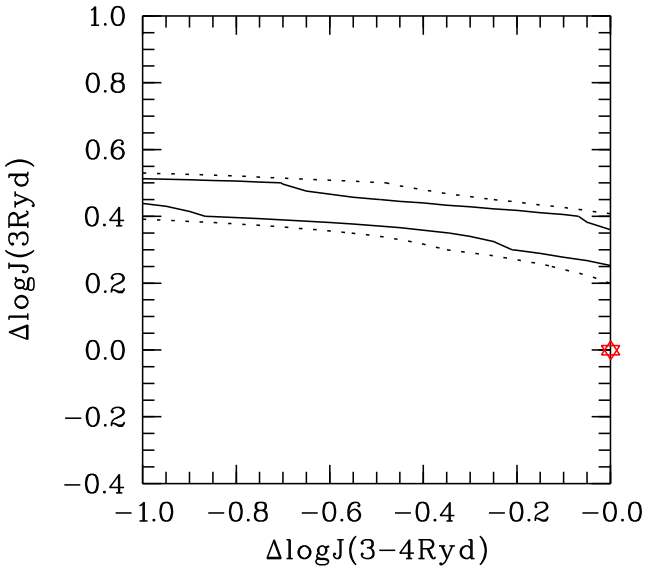
$$[\mathrm{Si/C}] = +0.41 \pm 0.16$$

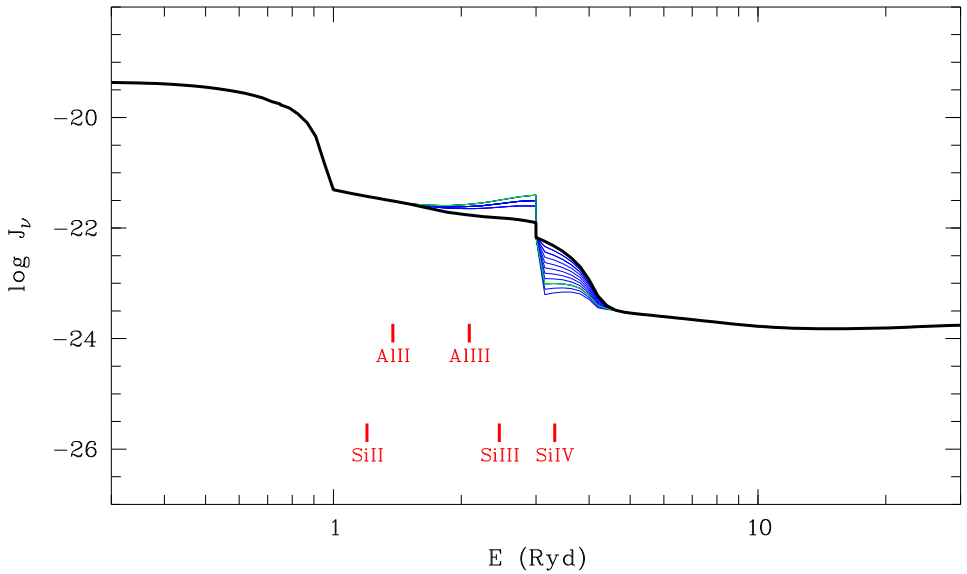
Test study with optical data – HE1347-2457

System at $z = 1.7529$ towards HE1347-2457 (UVES data)



The UV background at $z = 1.75$ towards HE1347-2457

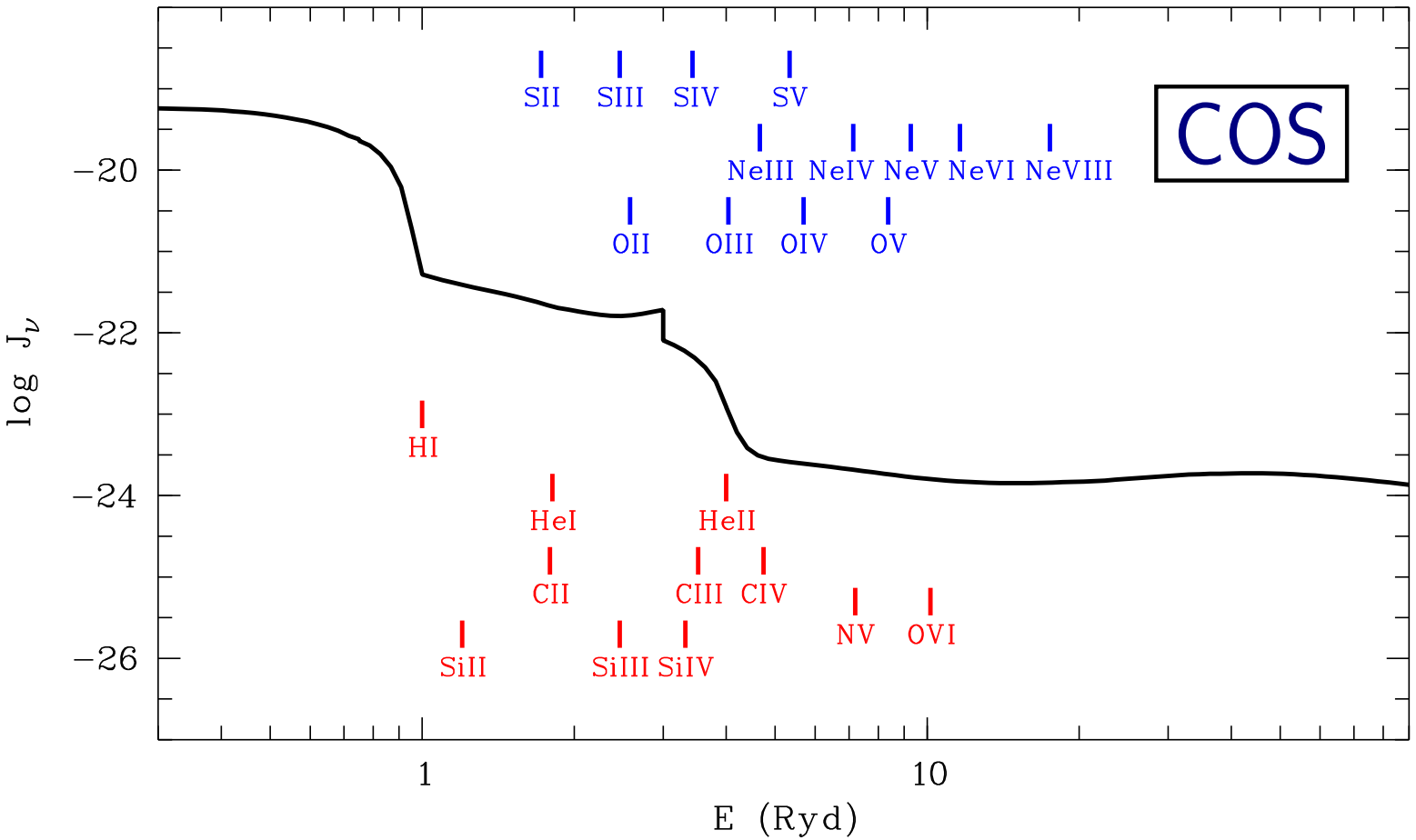




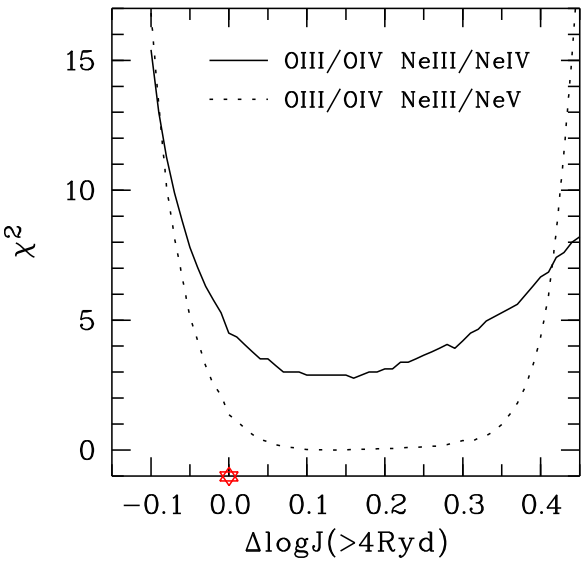
$\log U = -2.06 \pm 0.03$

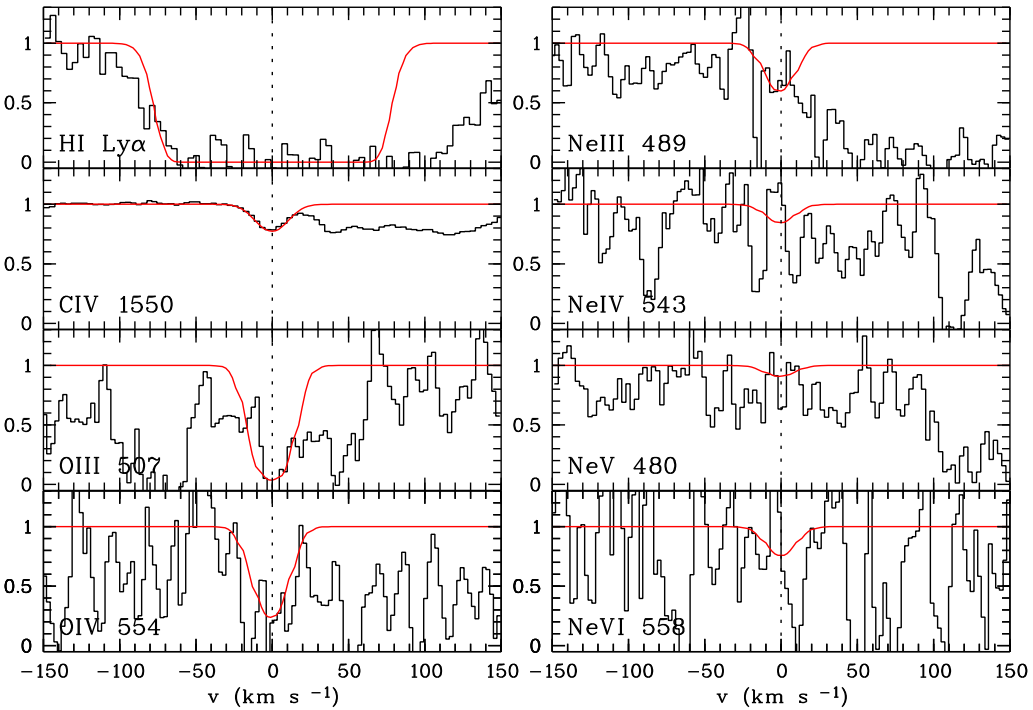
$[\mathrm{Si/H}] = -0.12 \pm 0.03$

Observable species



UV example: System at $z = 1.72$ towards HS1700+6416





(UV data from STIS E140M)

$\Delta \log J(> 4\,\mathrm{Ryd}) = 0.14 \pm^{0.21}_{0.12}$

$\Rightarrow$ UV background harder than HM01

$\Rightarrow$ S/N !

Summary and Outlook

- Investigation of 3 metal line systems in the optical:
  - indication for more pronounced peak of He II Lyα emission at 3 Ryd
  - spectra appear to be softer than HM01 at redshift $z > 2$

    (consistent with Agafonova et al. 2006 and Fechner at al. 2006)
- Preliminary study of one metal line system in the UV:
  - additional energy range is probed
  - indication for UV background harder than HM01 at $z < 2$

    (consistent with Agafonova et al. 2006)
- **COS** is needed:
  - spectra with sufficient S/N
  - increase number statistics of suitable (low-redshift) systems