The Gunn-Peterson Effect

Neutral hydrogen at high redshifts

At z~1100 the Universe was neutral. First sources start ionizing the Universe at z~20. Inhomogenous re-ionization, pockets of neutral H remains in the IGM. Neutral H absorbs Lyman-α photons (n=2 -> n=1) at λ=1216 Å. Cosmological redshift: absorption at shorter wavelengths at source -> absorption seen at longer wavelengths at observer. If neutral H present between source and us, expect absorption on the blue side (shortwards) of the Lyman-α emission line.

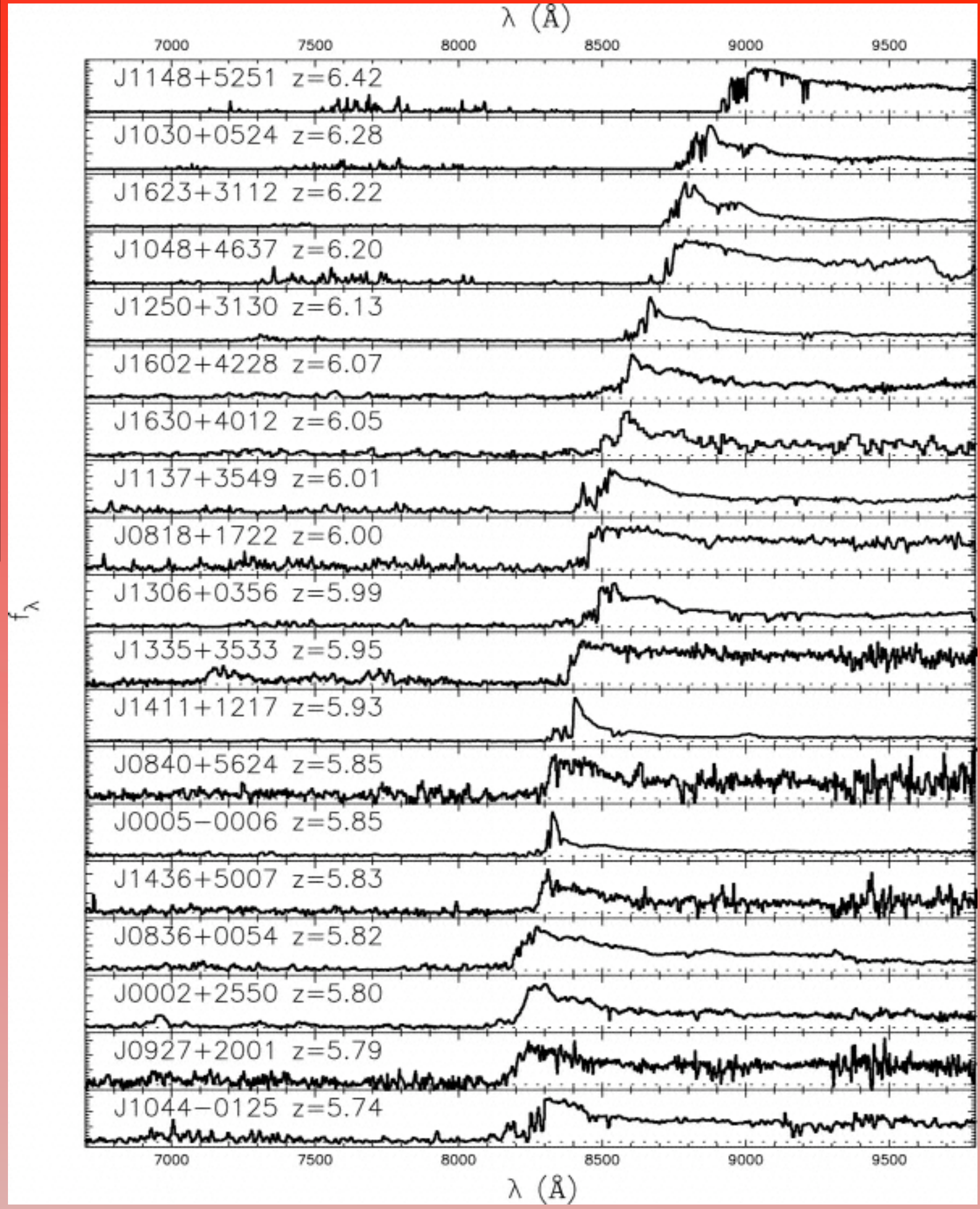
Gunn-Peterson effect (Gunn&Peterson, 1965, ApJ, 142, 1633).

$$\tau_{\rm GP} = \left(\frac{\pi e^2 f}{m_e c \nu_\alpha}\right) \frac{n_{\rm HI}(z)}{(1+z)} d_H(z)$$

$$\tau_{\rm GP} = 6.6 \times 10^3 h^{-1} \left(\frac{\Omega_B h^2}{0.019}\right) \frac{n_{HI}}{\bar{n}_H} (1+z)^{3/2}$$

The Gunn-Peterson effect as an observational tool

- A small amount of neutral HI result in large τ_{GP}. Gives the possibility to probe the spatial and temporal variation of re-ionization at high z.
- Comparisons between the observed τ_{GP} and the observed τ_{ES} from WMAP (Spergel et al., 2007, ApJS, 170, 377) give further constraints.
- In addition, the GP effect from HeII absorption at λ=304 Å has also been observed in a few quasars at 2.4< z< 3.2.



Fan et al., 2006, ApJ, 132, 117

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