High Redshift Galaxies and the Sources of Reionization

Two of the most outstanding issues in modern astrophysics are what reionized the Universe and how did the first objects form? We are attempting to address these questions in a series of VLT observations using the Lyman Break selection technique. To probe galaxies at the highest redshifts, we have obtained deep R-,I, and z-band exposures using FORS2 on the VLT. These images have 3σ detection limits in a 2 arcsec aperture of R_{AB}=27.6, I_{AB}=26.3, and z_{AB}=26.7. The galaxies are selected through their red colors in R-I and I-z. Our primary interest are galaxies with large R-I colors which probe redshifts between 4.8 and 5.8. With last semesters observations, we have now observed about 160 arcmin^2 or a completeness corrected co-moving volume of $\approx 4\times10^5$ Mpc^3. Follow-up observations using the FORS2 multi-object spectrometer have yielded a spectroscopic redshift determinations of about half the total sample of about 50 galaxies. The galaxies have star-formation rates of a few tenths to about 20 $M_\odot$ yr^{-1} as estimated from the strength of their UV continuum. The I-z colors of galaxies with $4.8<z<5.8$ are consistent with very young ages (<100 Myrs) and low extinction ($A_V<0.5$). The rest-frame UV spectra and sensitive X-ray flux upper-limits on similarly selected sources in the CDFS indicate that these sources are not generally AGN.
Overall, our results indicate that the Universe was reionized by stars and not AGN, with most of the ionizing photons arising in relatively faint low mass galaxies.

Lehnert, M. D., & Bremer, M. N. 2003, ApJ, 593, 630
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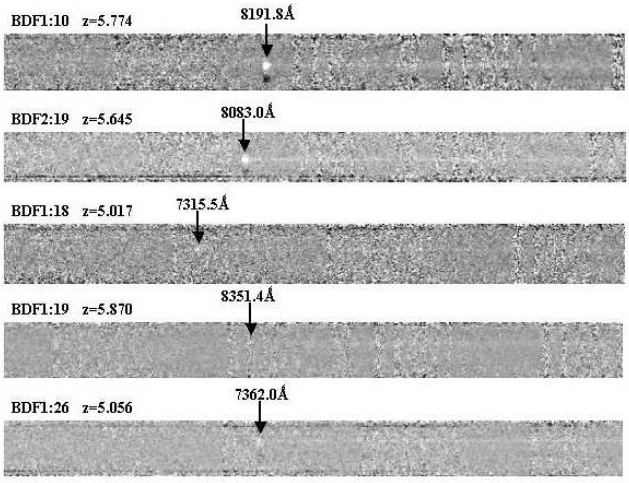
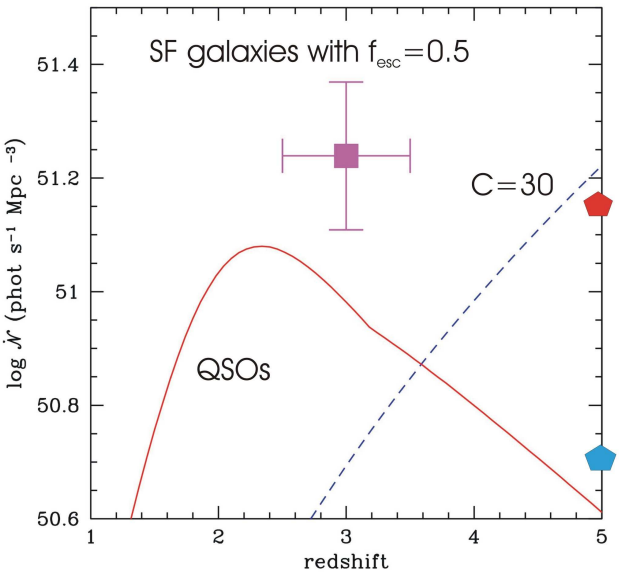
Two dimensional spectra of sources of break galaxies. The name and redshift are indicated above and to the left (blue) end of each spectrum and the wavelength Ly-alpha emission is indicated by the downward arrow. Continuum emission and then a break is visible in each. The lines show obvious redward asymmetries consistent with the line being Ly-alpha. These asymmetries are obvious even in the rendition for the top two spectra shown of the right.





A reproduction of a figure from Madau et al. (1999) which shows the number of ionizing photons per unit volume versus redshift. The solid red line shows the contribution from optically selected QSOs while the dotted blue curve shows the number of photons needed assuming a clumpy distribution of Hydrogen. The large solid purple square represents star-forming galaxies at z$\sim$3 assuming an escape fraction of 50%. The cyan hexagon represents the UV ionizing photon density we have observed at z$\sim$5.3, while the red hexagon is the UV ionizing photon density based an extrapolation of our best fit luminosity function to 0.2 L*. In both cases, the we assume escape fraction is 100%. This implies that for these sources to reionize even their local volume, they must have a high escape fraction and the Universe needs to have a relatively smooth distribution of Hydrogen.

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