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A *Spitzer*-IRS search for the galaxies that re-ionized the Universe

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Abstract. We describe an observation designed to find Hα emission from galaxies at $z \simeq 7-12$ made using the InfraRed Spectrograph (IRS) on the *Spitzer Space Telescope*.

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Spectra of the most distant quasars at $z \simeq 6.5$ show the Gunn-Peterson trough caused by absorption by neutral hydrogen in the ISM (White *et al.* 2003). The most recent analysis of the WMAP dataset is consistent with re-ionization at $z \simeq 11$ (Page *et al.* 2007). These observations suggest that starburst galaxies or quasars with large amounts of escaping UV emission were present at $z \simeq 7-12$, but such a population is inconsistent with a straightforward extrapolation of the evolution of known galaxy or quasar populations at $z \simeq 6$ (e.g., Bunker *et al.* 2004), unless the dominant stellar populations at $z \simeq 6$ is very metal poor (Stiavelli *et al.* 2004). Prior to re-ionization, Lyα emission is expected to be extinguished by a large (though uncertain) factor $\sim 10-100$ by the damping wing of the Gunn-Peterson trough (e.g., Santos 2006). This makes blank field Hα searches with *Spitzer* competative with ground-based near-infrared searches for Lyα.

We used the on *Spitzer*-IRS spectrograph to observe a single slit position aligned along the critical line for $z \gtrsim 7$ galaxies in the cluster Abell 2218 to demonstrate the feasibility of such observations. We used the second order short-low spectrum to search for Hα emission lines redshifted into the $5-9\,\mu$m range. We achieved a $3\,\sigma$ detection limit $\sim 2 \times 10^{-19}\,\mathrm{WHz^{-1}m^{-2}}$, corresponding to star formation rates $\sim 1000/\mu \mathrm{M_\odot yr^{-1}}$ where $\mu \simeq 10-100$ is the magnification factor. We have one candidate emission line detection at this level, which, if it is indeed Hα, is at a wavelength corresponding to $z = 9.8$.

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