UPPER LIMITS ON THE LYα EMISSION AT Z = 3.4

E. MARTINEZ-GONZALEZ, J.I. GONZALEZ-SERRANO, J.L. SANZ AND J.M. MARTIN-MIRONES
Dpto. Física Moderna, Univ. Cantabria and
Instituto de Estudios Avanzados, CSIC-Univ. Cantabria,
Facultad de Ciencias, Avda. Los Castros s/n, 39005 Santander, Spain

AND

L. CAYON
Lawrence Berkeley Laboratory,
1 Cyclotron Road, Berkeley, CA 94720, USA

Many searches have been carried out to detect emission from massive primeval hydrogen clouds at high redshift. By observing the 21 cm line it has been possible to impose strong upper limits on the mass and number of protoclusters at high redshift (Wieringa, et al. 1992). Since strong Lyα emission is expected from primeval galaxies undergoing their first burst of star formation, many attempts to detect this emission have been made, but no positive detection has been reported, imposing strong constraints on models of galaxy formation (see Djorgovski et al. 1993 for a review).

We have carried out deep CCD imaging of a particular region using a narrow-band filter isolating the Lyα line at a redshift of 3.4 at the 2.m Isaac Newton Telescope (Canary Islands, Spain). The seeing was poor $\approx$ 3".4. We have used PISA to search for objects in the frames.

We do not find any Lyα emitting object in an area of $\approx$ 120 arcmin^2 within the redshift interval 3.37 − 3.44. The surface brightness limit obtained is 4.3×10^{-18} ergs cm^{-2} s^{-1} arcsec^{-2} (1σ confidence level). We conclude that no source of size in the range 5"-10" (75-150 h^{-1}Mpc at z=3.4 for $\Omega = 1$) with line flux greater than 2.1×10^{-17} ergs cm^{-2} s^{-1} was present in the observed field at the 5σ confidence level. In other words, this limit implies that only unobscured Lyα emission objects 5 magnitudes fainter than the nearby radio galaxy $0902 + 34$ can exist within the searched area. We have arrived to a flux limit a factor 2 below the one given by Rhee et al. (1993) with no restriction on the size of the objects to be less than $5''$ and

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within an area ≈ 5 times bigger, being therefore the most stringent limit on Lyα emission at redshifts around ≈ 3.4. Moreover, considering limits on emission at other redshifts our flux limit slightly improves upon publised works with number density $\lesssim 50$Lyα emitters per square degree (see figure 1 of the recent review by Djorgovski, Thompson and Smith 1993 for 1σ flux limits).

The upper limit found on the Lyα flux can be used to constrain the models for the appearance of primeval galaxies proposed by Baron and White (1987).

A plausible explanation of the absence of Lyα emission from these observations and other sky surveys and from damped high redshift Lyα systems could be attenuation by dust. The Lyα photons can suffer a large number of resonant scattering in the ambient neutral atomic hydrogen, so this phenomenon can increase the chance for these photons to be absorbed by dust grains in contrast to the UV continuum ones. In such conditions, a 90 Å width filter as we have used in our observations may not be narrow enough to single out any Lyα feature.

Finally, we can obtain the expected Lyα emission from an HI cloud placed at $z = 3.4$ and with a 21 cm emission consistent with the upper limit given by the most recent radio observations of ≈ 2.3 mJy. Assuming a characteristic size for the cloud of $5'$ and a gaussian line-width of ~ 100 km s^{-1} the column density should be $N_{HI} \lesssim 10^{20}$ cm^{-2}. We have calculated the Lyα emission expected from a hydrogen cloud with the previous neutral column density, total hydrogen number density n_H ranging from $0.1 - 1$ cm^{-3} and a primordial abundance for the cloud of 24.5% of He by mass. For a quasar-dominated ionizing energy distribution ($I_\nu = J^0_{-21} \times 10^{-21}(\nu_c/\nu)$, with $\lambda_c = 912$ Å) the Lyα emissivity expected is $I_\alpha/J^0_{-21} \lesssim 3 \times 10^{-19}$ erg s^{-1} cm^{-2} arcsec^{-2}. This last upper limit is an order of magnitude below our observational upper limit. Therefore, the existence of HI clouds with the physical properties indicated above and at $z \approx 3.4$ is still possible considering present radio and optical observational constraints.

References

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