stead of recent massive star formation. The firm detection of an infrared continuum would help to constrain the characteristics and total mass of the stellar populations through comparison with population synthesis models.

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VLT Spectroscopy of the $z = 4.11$ Radio Galaxy TN J1338–1942

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High-redshift radio galaxies (HzRGs) play an important role in cosmology. They are likely to be some of the oldest and most massive galaxies at high redshifts, and can therefore constrain the epoch at which the first generation of stars were formed. The near-IR Hubble $K – z$ diagram of powerful radio galaxies shows a remarkably tight correlation from the present time out to $z = 5.19$, despite significant *K*-corrections (van Breugel et al. 1998, 1999). This indicates that we can follow the evolution of the hosts of HzRGs from near their formation epoch out to low redshift ($z \lesssim 1$), where powerful radio sources inhabit massive elliptical galaxies (e.g. Lilly & Longair 1984; Best, Longair & Röttgering 1998). For example, at $z \sim 3$, we observe a change in the observed K-band morphologies of HzRGs from large-scale low-surface brightness emission with bright radio-aligned clumps at $z \lesssim 3$ to smooth, compact structures, sometimes showing elliptical shapes, like their ocal Universe counterparts (van Breugel et al. 1998). These surrounding clumps have properties similar to the UV dropout galaxies at similar redshifts (Pentericci et al. 1999), and indicate that HzRGs often reside in (proto-)cluster environments. This evolution picture seems consistent with the hierarchical clustering formation models (e.g. Kauffmann et al. 1999), where massive objects form by accretion of smaller systems located in over-dense regions.

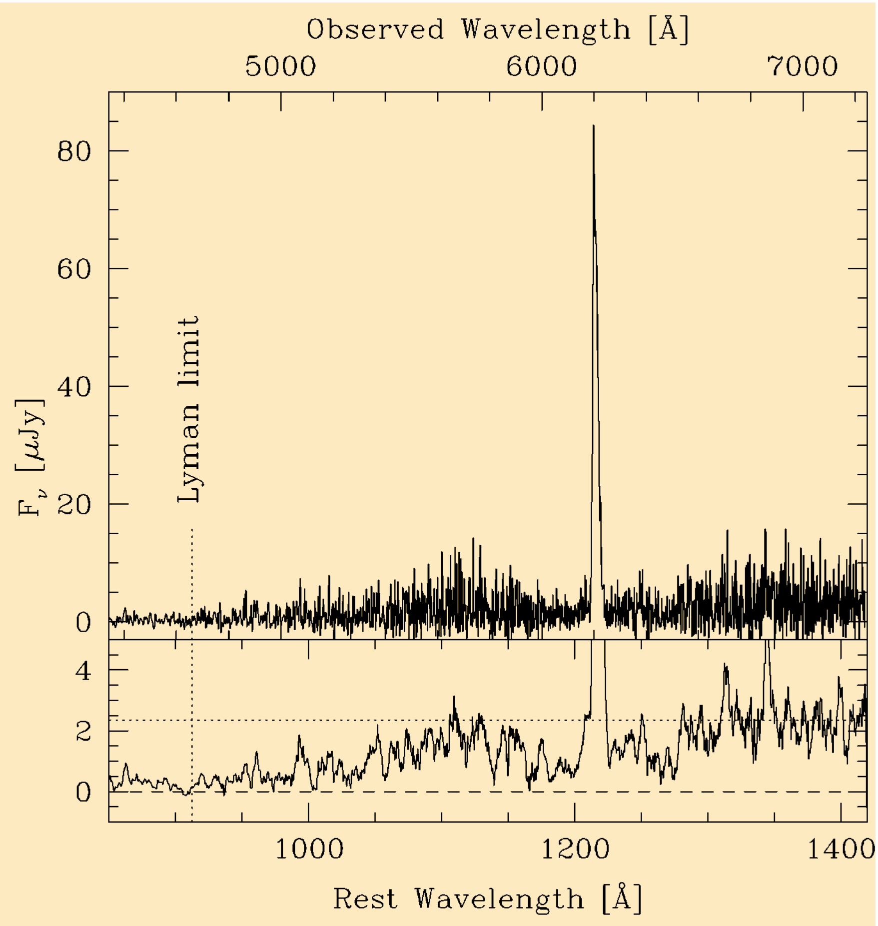

Figure 1: VLT spectrum of TN J1338–1942. The lower panel has been boxcar smoothed by a factor of 9 to better show the shape of the Lyα forest and the Lyman limit.

Detailed studies of HzRG can then be compared with the predictions of the hierarchical clustering scenarios.

Using newly available radio surveys, we have begun a systematic search for $z > 3$ radio galaxies (De Breuck et al. 2000), to be followed by more detailed studies of selected objects.

During the second week of VLT Antu operations in April 1999, we used FORS1 to obtain a spectrum of the second highest redshift radio galaxy from our sample, TN J1338–1942 at $z = 4.11$. We discovered this object in March 1997 using the ESO 3.6-m telescope (De Breuck et al. 1999a). The purpose of these VLT observations was to study the Lyα emission and the UV-continuum.

We used the 600R grism with a 1.3″ wide slit, and integrated for 47 min. The spectrum, shown in Figures 1 and 2, is dominated by the bright Lyα line ($F_{Ly\alpha} = 2 \times 10^{-15}$ erg s^{-1} cm^{-2}) with a rest-frame equivalent width of 210±50Å, a typical value for HzRGs.

Most notable from Figure 2 is the large asymmetry in the emission profile, consistent with a very wide (~ 1400 km/s) blueward depression over the entire spatial extent of the emission (~10 kpc). Similar asymmetries have been detected in other HzRGs, and have been interpreted as due to absorption by cold HI gas in a halo surrounding the radio galaxy (e.g. van Ojik et al. 1997; Dey 1999). The Lyα profile is well fit by a simple model consisting of a Gaussian emission profile and a single Voigt absorption function (see Figure 2). This model constrains the HI column density in the range $3.5 \times 10^{19} - 1.3 \times 10^{20}$ cm^{-2}. From this, we derive the total mass of the absorber at $2 - 10 \times 10^7$ $M_\odot$, which is comparable or slightly less than the total HII mass, as derived from the Lyα emission (De Breuck et al. 1999b). These results show that TN J1338–1942 is surrounded by a large reservoir of gas.

We also detect continuum emission in TN J1338–1942, only the second time this is reported in the spectrum of a $z > 4$ radio galaxy. The continuum, shown in the bottom panel of Figure 1, shows a discontinuity across the Lyα line, and a tentative detection of the Lyman limit. The flux deficit bluewards of Lyα is interpreted as HI absorption along the cosmological line of sight, and is described by the parameter

$$D_A = \langle 1 - \frac{f_\nu(\lambda 1050-1170)_{obs}}{f_\nu(\lambda 1050-1170)_{pred}} \rangle$$

(Oke & Korycanski 1982). For TN J1338–1942, we measure $D_A = 0.37 \pm 0.1$, similar to the $D_A = 0.45 \pm 0.1$ measured for the $z = 4.25$ radio galaxy 8C 1435+64 (Spinrad et al. 1995). Both these D_A values for $z > 4$ radio galaxies are significantly lower than the D_A values found for quasars at these redshifts (Schneider et al. 1991). Although based on only two measurements, our results suggest that the foreground HI absorption ($\equiv D_A$) in quasars could have been overestimated because the highest redshift ($z > 4$) quasars have been found from samples with an optical colour selection, thereby excluding quasars with relatively small breaks across Lyα.

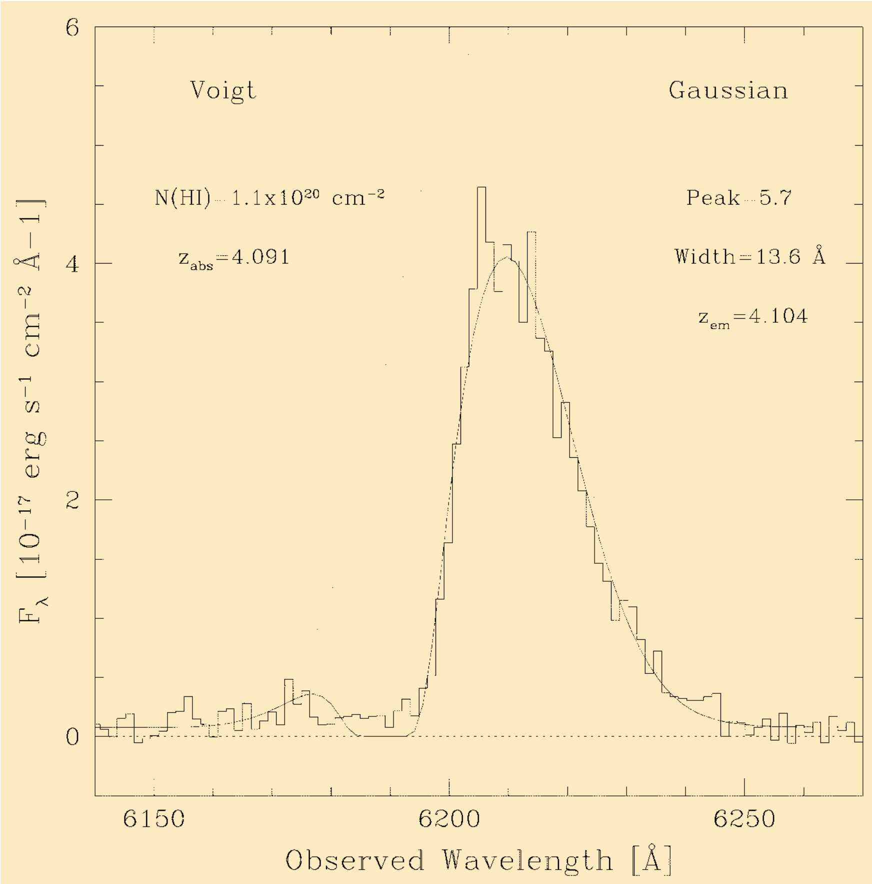

Figure 2: Part of the spectrum around the Lyα line. The solid line is the model consisting of a Gaussian emission profile (dashed line) and a Voigt absorption profile with the indicated parameters.

It is therefore particularly important to expand the number of objects at $z > 4$ selected by techniques other than optical colours. Radio galaxies are the brightest objects at these redshifts which are not out-shined by their central AGN like in quasars. Using the high sensitivity of the VLT instruments, we will be able to study at the same time the origin and evolution of their giant luminous halos or ionised gas, and the neutral HI gas surrounding them.

Acknowledgements. The work by C.D.B., W.v.B., D.M. and S.A.S. at IGPP/LLNL was performed under the auspices of the US Department of Energy under contract W-7405-ENG-48. D.M. is also supported by Fondecyt grant No. 01990440 and DIPUC. This work is supported in part by the Formation and Evolution of Galaxies network set up by the European Commission under contract ERB FMRX-CT96-086 of its TMR programme.

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