INTERMEDIATE RESOLUTION SPECTROSCOPY OF THE RADIO GALAXY B2 0902+34 AT $Z \approx 3.4$

J. L. SANZ, J. M. MARTíN–MIRONES, E. MARTíNEZ–GONZÁLEZ AND
J. I. GONZÁLEZ–SERRANO
Dpto. de Física Moderna, Universidad de Cantabria and
Instituto de Estudios Avanzados,
CSIC–Universidad de Cantabria
Facultad de Ciencias, Avda. de Los Castros s/n,
39005 Santander, Spain

We have carried out optical spectroscopic observations at intermediate spectral resolution of the massive high redshift radio galaxy 0902+34 at $z \approx 3.39$. This source was first identified by Lilly (1988) (from hereafter L88). The study of high redshift radio galaxies is interesting to analyze the physical conditions of the early universe and the galaxy evolution at cosmological redshifts. It has been claimed that some of these systems may be protogalaxies in the process of formation. Indications for this are the flat spectrum and the absence of the 4000 Å break, features which have already been observed in many cases. In particular, observations in the spectral range from V to K suggest that 0902+34 is a young galaxy (Eisenhardt and Dickinson 1992). Recent radio observations of the 21 cm line of neutral hydrogen have detected (Uson et al. 1991) an absorption against the radio continuum source. This absorption could also leave a track in the optical, redwards the Lyα line. Our observations were carried out with the ISIS spectrograph at the 4.2 m William Herschel Telescope (seeing $\approx$ 1.2–1.6 arcsec). A spectral dispersion of 0.78 Å/pixel (blue arm) and 1.38 Å/pixel (red arm) was obtained. A long slit of width 3" was used providing a spectral resolution of $\approx$ 5.4 Å in the blue arm and of $\approx$ 9.5 Å in the red one. Both resolutions are a clear improvement over that achieved by L88 of 20 Å, allowing us to resolve the Lyα line (and its possible structure) and any other possible strong features appearing in the spectral range observed (e. g., C IV λ1549, He II λ1640, ...). Six different observations of 2700 s of the radio galaxy 0902+34 were carried out. The slit was rotated to coincide with the parallactic angle at the beginning of each exposure. This will allow us to map spectroscopically

M. Kafatos and Y. Kondo (eds.), Examining the Big Bang and Diffuse Background Radiations, 499–500.

different regions of the galaxy (for more details see Martín-Mirones et al. 1994).

We have made two separate analysis of the data: individual spectra and summed spectrum. The observed properties of the lines detected in the summed spectrum appear in Table 1. We have arrived to the following conclusions:

– The Lyα and C IV lines have been resolved for the first time, whereas the He II line has been first detected and resolved in the present observation.

– The analysis of the line ratios in exposures with different orientations of the slit shows the existence of strong ionization and/or dust density gradients. Moreover, the ratios obtained are typical of radio galaxies with $z > 1.8$.

– We have also detected the optical continuum of the radio galaxy showing that it is almost flat in agreement with the recent conclusion, based on a much wider wavelength range, that 0902+34 is a young galaxy observed during its initial burst of star formation.

– Finally, the possible Lyα absorption corresponding to the H I cloud observed in 21 cm has not been detected by us. This result implies that either the absorbing cloud is in between the Lyα emitting region and the radio core or it is placed nearer us than the Lyα emitting region but with a maximum angular size in the range $\approx 0.00063 - 0.0063$" (of the order of tens of parsecs) for spin temperatures in the range $\approx 10^4 - 10^2$ °K.

TABLE 1: PROPERTIES OF THE LINES DETECTED

Property	Lyα	C IV	He II
Redshift	$3.3909^{+0.0004}_{-0.0003}$	$3.3969^{+0.0074}_{-0.0019}$	$3.3909^{+0.0015}_{-0.0012}$
FWHM (km s^{-1})	662^{+66}_{-66}	882^{+882}_{-209}	540^{+245}_{-147}
Surf. brig. (10^{-20} W m^{-2} arcsec^{-2})	$2.85^{+0.56}_{-0.49}$	$0.45^{+0.57}_{-0.22}$	$0.30^{+0.25}_{-0.18}$
Line surf. brig./Lyα surf. brig.	1.00	0.16	0.11
Equivalent width (Å)	182^{+36}_{-32}	55^{+70}_{-28}	43^{+36}_{-26}
Surf. lumin. (10^{35} W arcsec^{-2})[a]	$2.59^{+0.03}_{-0.03}$	$0.41^{+0.43}_{-0.10}$	$0.27^{+0.13}_{-0.08}$

[a] $H_0 = 50$ km s^{-1} Mpc^{-1}, $\Omega = 1$.

References

Eisenhardt, P.R.M., and Dickinson, M. (1992), *The Astrophysical Journal*, **Vol. no. 399**, L47.

Lilly, S.J. (1988), *The Astrophysical Journal*, **Vol. no. 333**, 161.

Martín-Mirones, J.M., Martínez-González, E., González-Serrano, J.I. and Sanz, J.L. (1994), *The Astrophysical Journal*, in press

Uson, J.M., Bagri, D.S., and Cornwell, T.J. (1991), *Phys. Rev. Letters*, **Vol. no. 67**, 3328.