UCRL-JC-131160
PREPRINT

The Highest Redshift Radio Galaxy Known in the Southern Hemisphere

C. De Breuck
W van Breugel
H. Rottgering
G Miley
C Carilli

This paper was prepared for submittal to the
"Looking Deep in the Southern Sky"
Sydney, Australia
December 9-12, 1997

December 1, 1997

Lawrence Livermore National Laboratory

The Highest Redshift Radio Galaxy Known in the Southern Hemisphere

Carlos De Breuck[1,2], Wil van Breugel[1], Huub Röttgering[2], George Miley[2] and Chris Carilli[3]

[1] Institute for Geophysics and Planetary Physics, Lawrence Livermore National Laboratory, L–413, P O Box 808, Livermore, CA 94550, U S A
[2] Leiden Observatory, P O Box 9513, 2300 RA Leiden, The Netherlands
[3] National Radio Astronomy Observatory, Socorro, NM ,U S A

Abstract We present the discovery of a $z = 4\ 13$ galaxy TN J1338-1942, the most distant radio galaxy in the southern hemisphere known to date The source was selected from a sample of Ultra Steep Spectrum (USS; $\alpha < -1\ 3$; $S \propto \nu^{\alpha}$) radio sources using the Texas and NVSS catalogs The discovery spectrum, obtained with the ESO 3 6m telescope, shows bright extended Ly-α emission The radio source has a very asymmetric morphology, suggesting a strong interaction with an inhomogeneous surrounding medium

1 Southern high redshift radio galaxy searches

High Redshift Radio Galaxies (HzRGs) may be used to study the formation and evolution of massive elliptical galaxies (see, *e g* van Breugel, this volume) However, the sample of HzRGs at the highest redshifts ($z > 3$) is extremely small, despite vigorous searches by several groups This is especially true in the southern hemisphere of the 20 $z > 3$ radio galaxies known, only 3 are in the South, below declination $-40°$, only one $z > 2$ radio galaxy is known!

To provide samples of HzRGs to study with the soon to be operational 6–8m class telescopes in the southern hemisphere (VLT, Gemini–South, Magellan), we have constructed a sample of USS sources from the TEXAS 365 MHz (Douglas *et al* 1996) and NVSS 1 4 GHz (Condon *et al* 1998) surveys ($\delta > -35°$), and from the MRC 408 MHz (Large *et al* 1981) and PMN 4 85 GHz (Griffith & Wright 1993) surveys ($\delta < -35°$) This USS selection makes our sample $\sim 65\%$ efficient in selecting $z > 2$ radio galaxies (see van Breugel, this volume, and De Breuck *et al* 1998)

2 The first southern $z > 4$ radio galaxy

The highest redshift USS object we have found thus far is the radio galaxy TN J1338-1942 The source has an integrated spectral index $\alpha = -1\ 33$, and a straight power-law spectrum between 365 MHz, 1 4 GHz and 4 8 GHz High resolution VLA imaging at 4 8 GHz and 8 3 GHz shows that the source has a core with $\alpha_{8\ 3}^{4\ 8} = -0\ 6$, a northwestern lobe with $\alpha_{8\ 3}^{4\ 8} = -1\ 6$ at $1''$ from the core, and a southeastern lobe with $\alpha_{8\ 3}^{1\ 8} = -2\ 5$ at 3″6 from the core (Fig 1) The coincidence of extended Ly-α emission with the NW lobe suggests that this asymmetry may be due to an inhomogeneous ambient medium

The R−band identification and spectroscopic observations were obtained with the EFOSC1 imaging spectrograph on the ESO 3 6m telescope We obtained two spectra, one covering 3725Å to 6940Å (not shown here), and another covering 6000Å to 9200Å (Fig 2) The 2″ slit used to obtain the blue spectrum was offset 2″ from the radio core, but nevertheless showed bright Ly-α , proving the large extent of the Ly-α emission

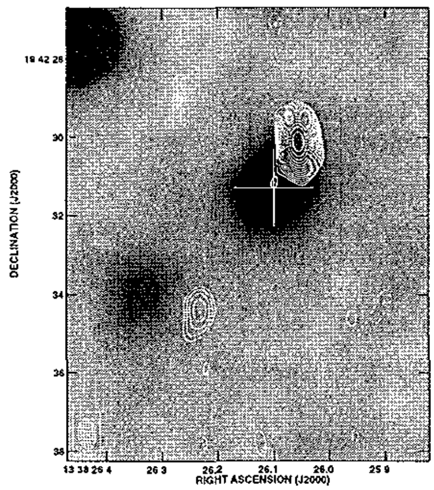

Figure 1. *Greyscales:* R−band image (t_{int} = 10 min, 1″3 seeing), dominated by Ly-α emission in the passband *Contours:* VLA 4 71 GHz map showing the asymmetric lobes The flat-spectrum core is indicated by a cross

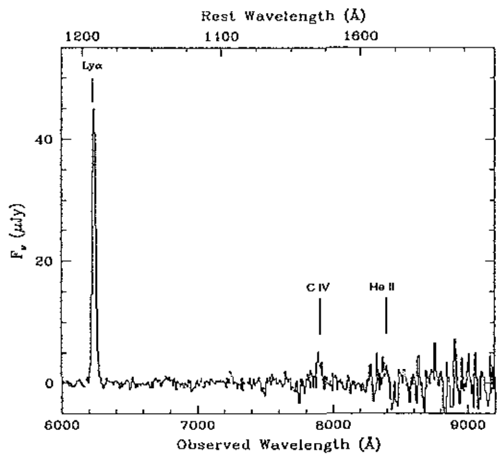

Figure 2. ESO 3 6m spectrum of TN J1338−1942 (t_{int} = 105 min) The bright (1×10^{-15} erg $s^{-1}cm^{-2}$) Ly-α is extended (6″ ; ∼ 50 kpc) and has spatially extended absorption on the blue side, as seen in many $z > 3$ radio galaxies (*e g* Dey 1998) Weak C IV and He II lines confirm the redshift $z = 4\ 13$

Acknowledgments The research at IGPP/LLNL is performed under the auspices of the US Department of Energy under contract W–7405–ENG–48

References

Condon, J J , *et al* 1998, AJ, 115, 1693

De Breuck, C , *et al* 1998, in Proc Radio Surveys Workshop, Tenerife Spain, ed M Bremer (Dordrecht: Kluwer), p 185

Dey 1998, in Proc *The Most Distant Radio Galaxies,* Amsterdam, The Netherlands, in press, astro-ph/9802163

Douglas, J , *et al* 1996, AJ 111, 1945

Griffith, M , & Wright, A E 1993, AJ, 105, 1666

Large, M I , *et al* 1981, MNRAS, 194, 693

Technical Information Department • Lawrence Livermore National Laboratory
University of California • Livermore, California 94551