Lyα excess in high z radio galaxies: A signature of star formation

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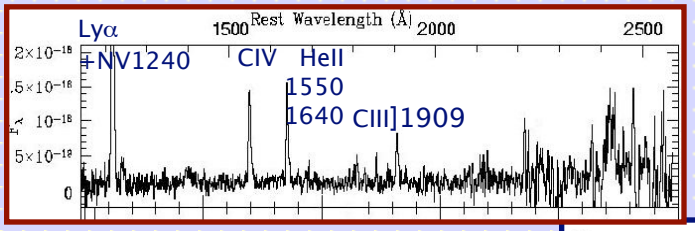
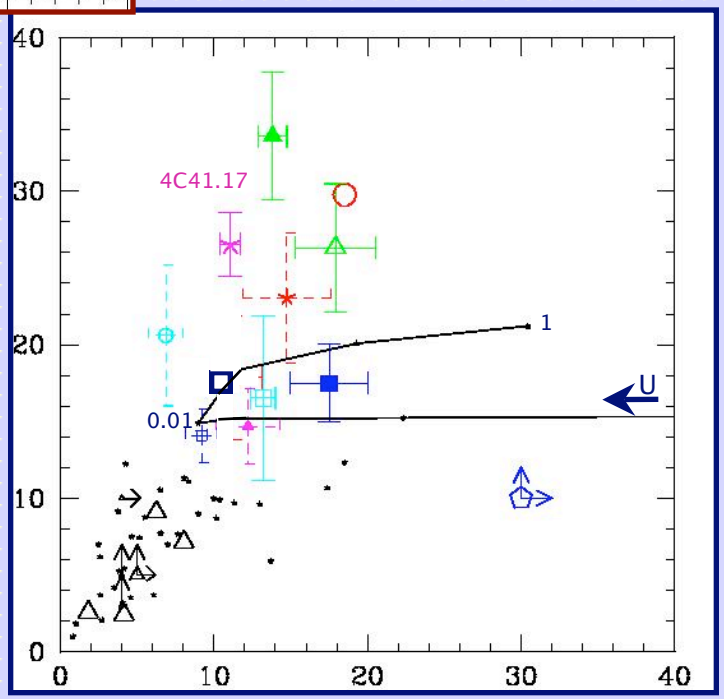
Villar-Martín et al., 2007, MNRAS, 375, 1299

Lyα excess in high redshift (z>2) radio galaxies





Small: 2≤z<3
Large: z≥3
Coloured: LAEs

Power law, index −1.5, n=100, solar abundances, U sequence

Sample of z>2 (→ Lyα) powerful radio galaxies in the literature with good S/N spectra

(see also De Breuck et al. 2000

Classification according to redshift

z range	Lyα/HeII	Lyα/CIV	$P_{1400\ MHz}$ (10^{35} erg/s/Hz)	Radio size ('')	L(Lyα) (10^{44} erg s^{-1})
2≤z<3 (48 objects)	8.00 (4.75)	6.90 (4.21)	1.39 (1.23)	9.5 (10.4)	0.44 (0.79)
z≥3 (13 objects)	17.50 (10.90)	10.60 (5.41)	1.66 (1.36)	5.0 (4.80)	1.35 (1.03)
Ratio	2.0	1.5	1.2	~1/2	3.0
P (Kolmogorov–Smirnov test)	99%	96.5%	14%	89%	93%

Red Nrs.: Median Green Nrs.: Standard deviation

61% (8/13) of z≥3 radio galaxies and 8% (4/48) of 2≤z<3 radio galaxies ...

LAEs

- unusually strong Lyα emission
- Lyα/HeII consistent with or above standard photoionization model predictions (15–20)

A young stellar population

$L(Ly\alpha)_{exc} \sim L(Ly\alpha)_{LAEs} - L(Ly\alpha)_{non\text{-}LAEs}$

$\sim 10^{44}$ erg s^{-1}

f^{1550} (z~3.5) ~(0.5–1.6) x 10^{-18} erg s^{-1} cm^{-2} Å^{-1}

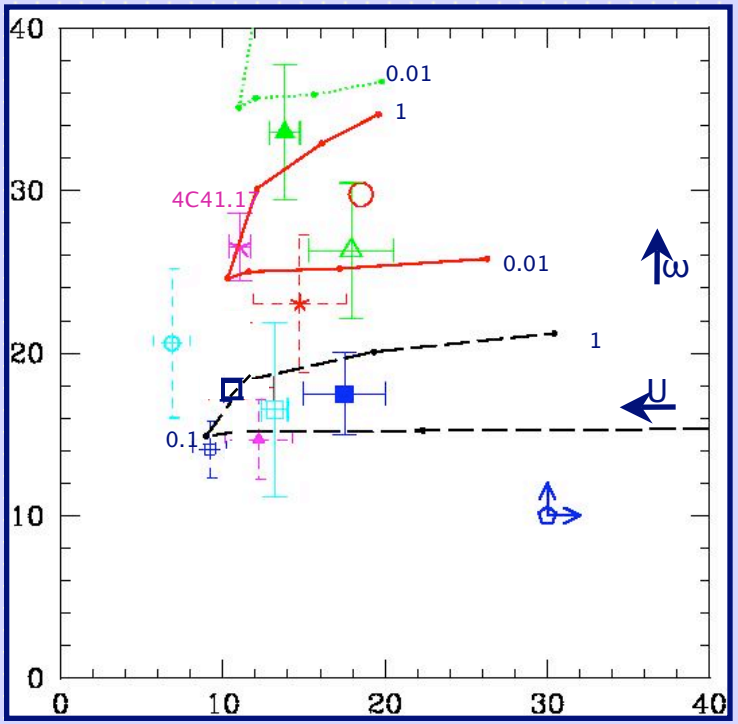
$Q^{abs}_{ion} \sim 10^{55}$ s^{-1}

SFR ~ several hundred M$\odot$ yr^{-1}

Vernet et al. 2001→ ≤few 100 $M_\odot$ yr^{-1} (opt. cont)

Archibald et al. 1999 → >1000 $M_\odot$ yr^{-1} (submm)

Young stars contribute to the Lyα luminosity of 38% z≥3 RG



Lyα/ HeII

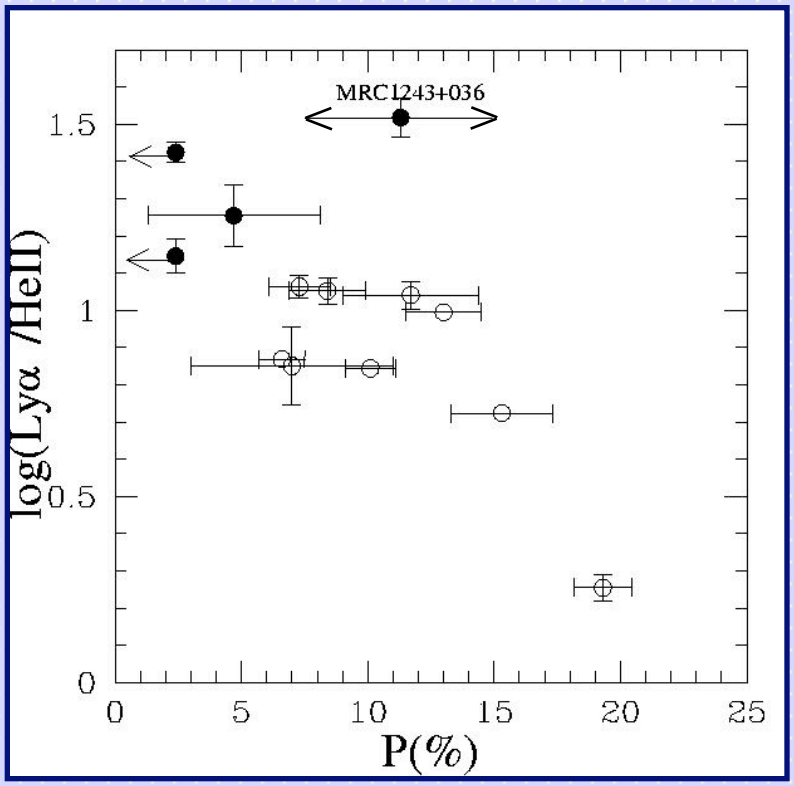
Lyα/ CIV

5 Myr
Solar Metallicity
U=0.2
Salpeter IMF

$\omega = Ly\alpha_{Stars} / Ly\alpha_{AGN}$

ω = 0 - - - - -
ω = 0.7 ——
ω = 1.5 ·····

Because of absorption, the fraction may increase to 61% at z≥3 and 8% at 2≤z<3



● LAEs

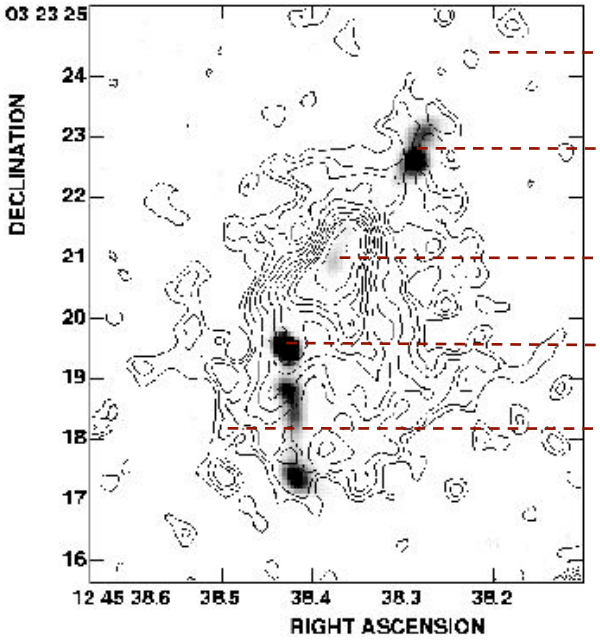
LAEs show lower optical continuum polatization than non-LAEs

Young stellar population

(See also Vernet et al. 2001)

Star formation at tens of kpc from the nuclear region

MRC 1243+036 (z=3.6)



(Van Ojik et al. 1996)

Lyα / HeII

>4

0

26 ±5

33.3±0.3

29±4

34 ±15

(Models ~ 15–20)

See also Maxfield et al. (2002)
Heckman et al. (1991)

Star formation activity is more intense in z>3 radio galaxies

Submm studies
(e.g. Archibald et al. 2001, Stevens et al. 2003)

Detection rate of HzRG increases dramatically between z<2.5 and z>2.5

Average submm luminosity $\alpha(1 + z)3$ up to z~4

Optical polarization studies
(De Breuck et al. 2003)

P(%) deacreases with redshift

More intense star formation in z>3 radio galaxies

Larger Lyα luminosities and ratios

Why does the fraction of LAEs increase with z?

Higher z radio galaxies are younger
(dense post-recent merger environment)

Blundell & Rawlings (1999)

Younger ages

Strong jet-gas interactions

Seen after recent activity of mergers/interactions

Small radio sources

E.g. FWHM (>1000 km/s)

Enhanced star formation

Increasing fraction of LAEs at z>3

Classification according to Lyα excess

Object class	z	$P_{1400\ MHz}$	LAS Radio size (kpc)
Non-LAEs (39 objects)	2.48 (0.42)	1.23 (1.60)	85.2 (74.7)
LAEs (12 objects)	3.57 (0.68)	1.25 (1.29)	18.5 (38.8)
Ratio		1.0	1 / 4.6
P	98%	49%	90%

Red Nrs.: Median

Green Nrs.: Standard deviation

LAEs are associated with smaller radio sources

Summary and conclusions

•About 61% of z≥3 and 8 % of 2 ≤ z <3 show unusually strong Lyα emission

• These 'Lyα excess' objects show Lyα/HeII values consistent or above standard photoionization model predictions

• Stellar photoionization is the most successful explanation

• Star formation activity was more intense at z>3 → consistent with submm and optical polarization studies

• We propose that, the environment density increases with z → smaller radio sources, more signatures of jet-gas interactions, higher star forming rates → Fraction of LAEs increases

•Alternatively, at the highest z, we are selecting young radio galaxies

•According to the Lyα/HeII values, star formation can extend for tens of kpc

•We propose that high Lyα/HeII values (>20) in the extended gas of radio galaxies and quasars might indicate high star formation activity (vs. low gas metallicities)