

Neutral hydrogen absorption at milliarcsecond resolutions:-The radio galaxy 3C 293

Rob Beswick

(Jodrell Bank Observatory)

Alison Peck (SMA) Greg Taylor (NRAO) Alan Pedlar (JBO) Gabriele Giovannini (CNR) Paddy Leahy (JBO) Neal Jackson (JBO)

14th October 2004

EVN Symp 2005

1



Overview

1. Overview of the radio galaxy 3C293

- 2. Summary of observational results
 - Lower resolution VLA & MERLIN observations
 - HST/MERLIN observations of the jet
 - Combined VLBI, MERLIN & VLA observations of HI absorption & radio jet



Introduction & Observations

- 3C293
 - Nearby Radio galaxy (D=180Mpc; implies 1" = 815pc)
 - Significant signs of merger (dust lanes, a nearby companion galaxy)
 - Significant gas content (CO, Evans et al 1999 & HI)
 - Fast gas outflows (Morganti et al 2003)
 - Large scale radio jets/lobes
 - Steep spectrum core
- Observations
 - Radio: 1.4 GHz VLA, MERLIN & Global VLBI, 5GHz MERLIN continuum (JET & HI absorption)
 - Optical/IR : HST, NICMOS. (IR Jet)



Large to intermediate scale jets

VLA B-config 1.35GHz
Double ~100kpc scale jet

• Bright central core region

 Inner jet PA ~90 degrees (Significant change compared to large scale jet)

(Beswick et al 2004)

31 28 30 **VLA 1.35GHz** 50 kpc 00 27 30 00 26 30 00 MERLIN 25 30 00 13 62 18.00 17.70 20 13 52 25 15 10 **RIGHT ASCENSION (J2000)**

14th October 2004

EVN Symp 2005

ECLINATION (J20



The inner jet

- At sub-arcsec angular resolutions the inner central few kiloparsec radio jet breaks into multiple components along an east-west orientation.
 - Steeply inverted spectrum of core
 - $\alpha \sim -1$ (Akujor et al 1996)
 - Fitted core size <17pc





The inner jet

- At sub-arcsec angular resolutions the inner central few kiloparsec radio jet breaks into multiple components along an east-west orientation.
 - Steeply inverted spectrum of core
 - $\alpha \sim -1$ (Akujor et al 1996)
 - Fitted core size <17pc





Infrared jet

• HST imaging of the centre of 3C293 at 1.6µm reveals a string of knots of emission coincident with the knots observed in the radio emission





Infrared jet





Infrared Jet

•Approaching eastern Shows weak optical/IR jet emission coincident with the inner radio jet components





The neutral ISM

- 3C293 is a very distorted and dust rich radio galaxy
- Extensive ~NE-SW dust lanes





HI absorption

- Very broad & deep HI absorption seen in sensitive WSRT observations.
- Outflows Jet-ISM interactions.... Toward the inner eastern jet??



(Morganti et al 2003)



HI Absorption

- Extensive MERL
 absorption
- Eastern side :-Narrow absorpti
- Western side :- 46.8 broad(er) absorr
- Opacities ~0.01-
- N_H ~10²¹ atoms⁻





HI distribution

- The dust distribution is strongly correlated with areas of increased HI opacity.
 - Dust and Neutral gas spatially related
 - In particular the narrow HI absorption traces the dust lanes





HI distribution





Narrow absorption

- At mas angular resolution the velocity structure of the narrow component is resolved against the eastern jet.
 - Small velocity gradient
 - Gas and dust rotating in the out reaches of the source.
 - VG ~ 50kms⁻¹arcsec⁻¹





Position-Velocity

- On ~200mas angular scales. Velocity gradient centred upon the core(?)
- Or two distinct velocity structures (??)

However stepping up the resolution the absorption breaks up many composite components.
Lack of illuminating background continuum.

MERLIN – 200mas angular resolution





Position-Velocity

- On ~200mas angular scales. Velocity gradient centred upon the core(?)
- Or two distinct velocity structures (??)

However stepping up the resolution the absorption breaks up many composite components.
Lack of illuminating background continuum.





Conclusions

- 3C293 is both an unusual and enigmatic radio galaxy.
- Steeply inverted radio core
- Radio/IR jet
 - Large PA shifts in the radio jet alignment
 - Jet interaction with the ISM and/or multiple outbursts of activity
 - (- interaction induced??)
- Extensive HI absorption
 - Deep nuclear absorption (N_H~10²¹ atoms cm⁻²)
 - Narrow absorption is strongly correlated with the dust distribution
 - Broad absorption toward the core and western jet
 - Possible velocity gradient in lower resolution data. Implies central mass <10⁹ solar masses (r<few hundred parsecs)
 - At mas resolution gradient breaks up can be interpreted as independent gas structures.
 - Do not have sensitivity or bandwidth to confirm location of broad HI outflows