RADIO JET AND LOBE OF 3C273

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ABSTRACT. The 'superluminal' motion observed in the cores of radio sources such as 3C273 is now accepted as evidence of relativistic motion within a few parsecs of the centre, but it is less clear whether such speeds persist out to kiloparsec scales. The one-sidedness of such sources is often cited as evidence of relativistic Doppler beaming, but could equally be intrinsic. New MERLIN maps of 3C273 at 151 MHz and 408 MHz have been made with dynamic range of 4.10^3:1 and 10^4:1 respectively. These show that (i) there is an extended region or lobe to the south of the main jet; (ii) the radio emission of the jet is continuous from the core to beyond the limit of the optical jet; (iii) no counter-component can be found in the opposite direction to the jet. The ridge-line of the jet shows a 'wiggle', the wavelength of which decreases by a factor of 6 along its length. This is interpreted as a deceleration of the bulk flow along the jet.

1. INTRODUCTION

3C273 is the archetype of a one-sided source which also shows superluminal motion[1]. This quasar has redshift 0.158 and taking H_o = 100 km/s/Mpc 1" corresponds to 1.85 kpc. There is good evidence for relativistic flow at least in the nucleus, and it is tempting to consider whether the extended one-sided emission is due to Doppler effects. If relativistic flow is causing Doppler boosting in the nucleus, and if the kpc jet is moving slowly, then such a source inclined away from the line of sight (l.o.s.) would appear as a disembodied jet pointing back to a radio quiet quasar and such sources are not seen. It is thus of great interest to observe with very high dynamic range at low frequency to detect any old slow moving components which may be associated with any invisible counter jet.

2. OBSERVATIONS AND RESULTS

Measurements of the low frequency spectrum and angular diameters of 3C273 led Foley and Davis[2] to predict the presence of an extended halo

G. Swarup and V. K. Kapahi (eds.), Quasars, 211–214.

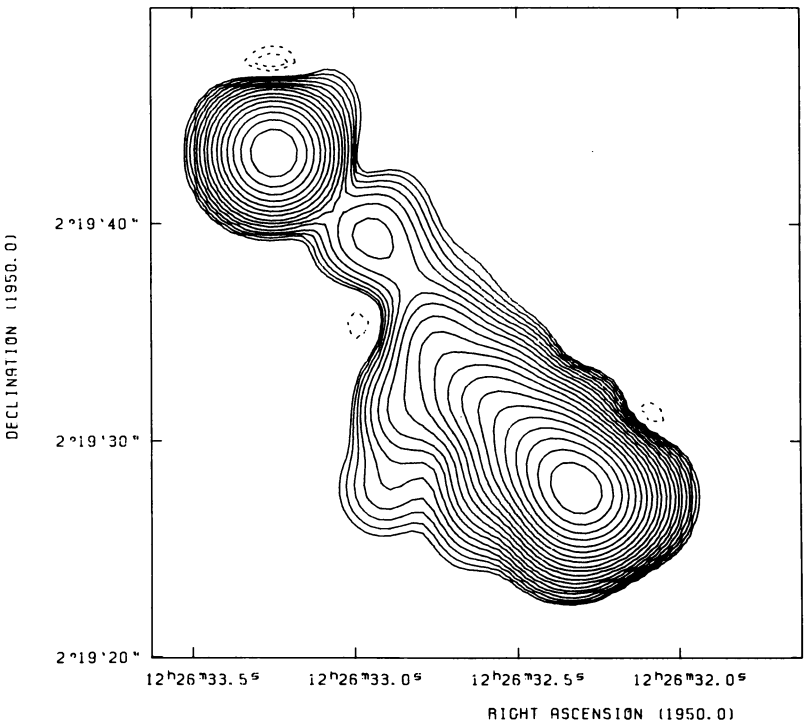

Fig. 1

MERLIN map of 3C273 at 151 MHz

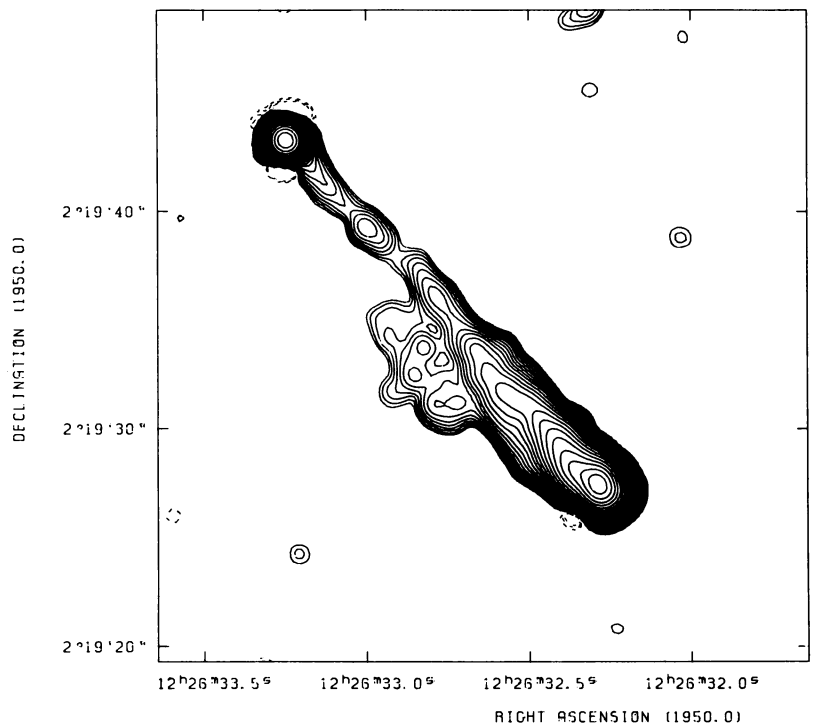

Fig. 2

MERLIN map of 3C273 at 408 MHz

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which should be observable at 151 MHz and they expected the halo to surround the whole source as in 3C345[3] and thus allow the Doppler model to explain the one-sided nature of the source. Recent advances in the closure technique[4] have been made at Jodrell Bank enabling maps to be made down to the thermal noise. Fig. 1 shows a new 3×10^3:1 dynamic range MERLIN 151 MHz map, and Fig. 2 shows 1981 data at 408 MHz from MERLIN reprocessed with the new Starlink computer and software giving a 10^4:1 dynamic range map. The new data show a jet continuous from nucleus to outer hotspot and a steep spectrum ($\alpha = 1.5\pm.3$) extended region or "lobe" on the south side of the jet ($\alpha = 0.80\pm.05$). Nothing above the noise level is seen on the other side.

3. DISCUSSION AND CONCLUSIONS

3.1. Side to side ratios

A cut made along the jet but in the opposite direction to the jet gives a peak to peak ratio of 5500:1 between the brightest region of the jet to the highest noise spike on the other side. Some radiation from the jet could be Doppler boosted but there are arguments[5] that at least one sixth is moving slowly and this gives an intrinsic side to side ratio of >1000:1. The strongest arguments come from the lobe. This is 15 (arc s)^2 on the 408 MHz map and no region of equivalent area on the other side has one fiftieth of the flux density. Thus peak to peak lobe to counter lobe ratio is >50:1.

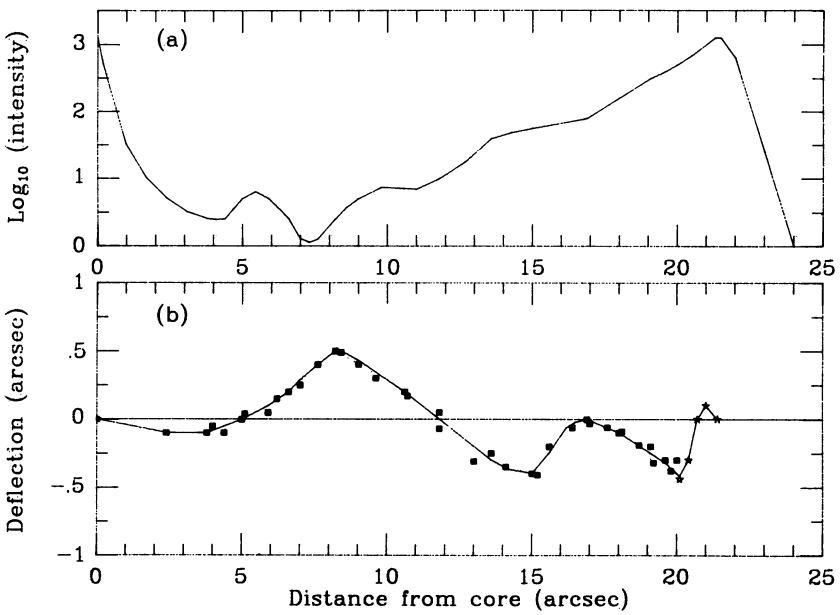

Fig. 3 (a) Plot of intensity along the ridge of the jet.
(b) Sideways deflection of ridge-line.

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3.2. Wiggle

Fig. 3 shows that the wavelength of the wiggle in the ridge line of emission decreases monotonically by a factor of 6 as the radio brightness increases along the jet. This is interpreted as a deceleration of the bulk flow: energy being dumped in the synchrotron reservoir. Strictly this results in a reduction of $\beta_{obs}c$:-

$$\frac{c\ \beta\ \sin\ \theta}{(1\ -\ \beta\ \cos\ \theta)}$$

which, if 3C273 is close to the angle to the l.o.s. (θ) for maximum superluminal velocity, reduces to $\beta\gamma c$. One can argue about velocities at each end of the jet a) superluminal flow in nucleus $\gamma\beta \simeq 5$, b) ram pressure arguments concerning the working surface at the head of the jet $\gamma\beta \simeq 0.1$[6], but the new observable is that $\gamma\beta$ or more strictly β_{obs} changes by 6 along the jet. One can then start to build a consistent model for the dynamics of this source.

3.3 Conclusion

It appears that Doppler beaming is insufficient to hide any lobe counterpart and probably it is insufficient to hide any counter head. 3C273 contains all the ingredients of a classical double source like Cygnus A, with core, jet, hotspots, wiggle, extended lobe, but on one side only.

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REFERENCES

1. Pearson, T.J. et al., Nature 290, 365, (1981).
2. Foley, A.R. & Davis, R.J., Mon.Not.R.astr.Soc. 216, 679,(1985).
3. Schilizzi, R.T. & de Bruyn, A.G., Nature 303, 26, (1983).
4. Cornwell, T.J. & Wilkinson, P.N., Mon.Not.R.astr.Soc. 196,1067,(1981).
5. Flatters, C. & Conway, R.G., Nature 314, 425, (1985).
6. Conway, R.G., Davis, R.J., Foley, A.R. & Ray, T.P., Nature 294, 540, (1981).