Radio Interferometry: Theory, Techniques and Applications,
IAU Coll. 131, ASP Conference Series, Vol. 19, 1991,
T.J. Cornwell and R.A. Perley (eds.)

MERLIN OBSERVATIONS OF SUPERLUMINAL MOTION IN THE JET OF 3C120

T.W.B. MUXLOW
N.R.A.L., Jodrell Bank, University of Manchester, Macclesfield, Cheshire, SK11 9DL, U.K.

P.N. WILKINSON
N.R.A.L., Jodrell Bank, University of Manchester, Macclesfield, Cheshire, SK11 9DL, U.K.

ABSTRACT We present evidence for changes in the radio structure of the jet in 3C120 between December 1980 and December 1988 derived from MERLIN observations at 1.67 GHz. The changes are consistent with outward motion of 19±2 mas (2.4 ±0.3 mas yr^{-1}, i.e. $3.5 \pm 0.4h^{-1}$ c, for $H_0 = 100h$ km s^{-1} Mpc^{-1}) in the inner jet, about 0.15 arcsec ($\sim 75h^{-1}$ pc) from the core. This confirms the suggestion by Benson *et al.* (1988) that the jet does not slow down quickly just outside the core region usually imaged by VLBI. However, we find no evidence for motion at the position of the knot 4 arcsec ($\sim 2h^{-1}$ kpc) from the nucleus as suggested by Walker *et al.* (1988). Our limit is 1.26 mas yr^{-1}, i.e. $<1.8h^{-1}$ c, compared with Walker *et al.* 's measurement of 2.4 ± 0.8 mas yr^{-1} i.e. $3.7 \pm 1.2h^{-1}$ c.

INTRODUCTION

The radio galaxy 3C120 (z=0.033) has a long bright jet which exhibits superluminal motion near the nucleus. Angular velocities up to 2.5 mas yr^{-1} are seen corresponding to $\sim 4h^{-1}$ c). A recent VLBI study of 3C120 by Benson *et al.* (1988) suggests that superluminal motion, with the same apparent speed as seen in the parsec scale jet, persists out to 0.05 arcsec and probably to 0.1 arcsec (i.e. $\sim 50h^{-1}$ pc) from the core. Walker *et al.* (1988) recently reported evidence for undecelerated superluminal motion in 3C120 in a knot in the jet 4 arcsec ($\sim$ 2 kpc) from the nucleus. Using the VLA at 5 GHz they measured an outward shift of the knot of 9 ± 3 mas ($\sim$ 1/40th of the beam) in 3.75 years.

OBSERVATIONS

Our first epoch data were obtained in December 1980 (1980.98) using the Mk2 telescope (25 m) as the homestation element. At this time the MERLIN receivers were uncooled and typical system temperatures were around 80 K. Our second epoch data were obtained in December 1988 (1988.92) with a number of important improvements. By this time all receivers were cooled with typical system temperatures around 35K. In addition, the homestation element used was the 76 m Lovell telescope.

DATA REDUCTION AND IMAGE COMPARISON

Both data sets were initially processed using the Jodrell Bank OLAF software package. We registered the images by self-calibrating the 1980 data starting from the point source components which make up the 1988 image, modified in flux density at the central, brightest, pixel to account for core variability. The flux density of the central compact component in our images varied between our two epochs by 0.2 Jy - about a 7% change. If no action is taken to account for variability, then registering the 1980 and 1988 images via the *centroid* of the central compact component would produce an apparent eastward shift of the outer jet components of $\sim$ 7 mas – thus mimicking a contraction. Therefore rather than using the centroid of the central compact component *we used the brightest pixel as our fiducial point.* The images are shown in Figure 1. Component displacements were then found by subtracting the later epoch image from the earlier map; these then appear as ripples in the difference image. Displacement values were then found from the formal fit, pixel by pixel, to the slope between the gradient of surface brightness and the difference image.

Reliability was investigated by an extensive programme of simulations in which faked data were created from models of 3C120. The data contained realistic noise and aperture coverage and test component shifts between 5 and 20 mas. Finally, gain and phase errors were introduced into the fake data. These simulations showed that 5 mas shifts should be easily found in the inner jet region about 150 mas from the core and that at the 4 arcsec knot 10 mas shifts should be unambiguously detectable.

RESULTS

We detect outward motion of 19 ± 2 mas ($\sim$ 1/20th of the beam) in 7.94 years in the inner jet region about 150 mas from the core in 3C120. We do not however detect motion in the 4 arcsec knot. From our simulations, we place a conservative upper limit of 10 mas on the motion of this component. Figure 2 shows the difference image profiles along the jet in 3C120 for (i) The observed data, and (ii) The simulated data containing both gain and phase errors with a 20 mas shift. Figure 3 shows the observed difference image in greyscale overlayed on the contours of the 1988 image.

REFERENCES

Benson, J.M., Walker, R.C., Unwin, S.C., Muxlow, T.W.B., Wilkinson, P.N., Booth,R.S., Pilbratt, G., and Simon, R.S. 1988, *Ap.J.*, **334**, 560.

Walker, R.C., Walker, M.A.,and Benson, J.M. 1988, *Ap.J.*, **335**, 668.

https://doi.org/10.1017/S0252921100013531 Published online by Cambridge University Press

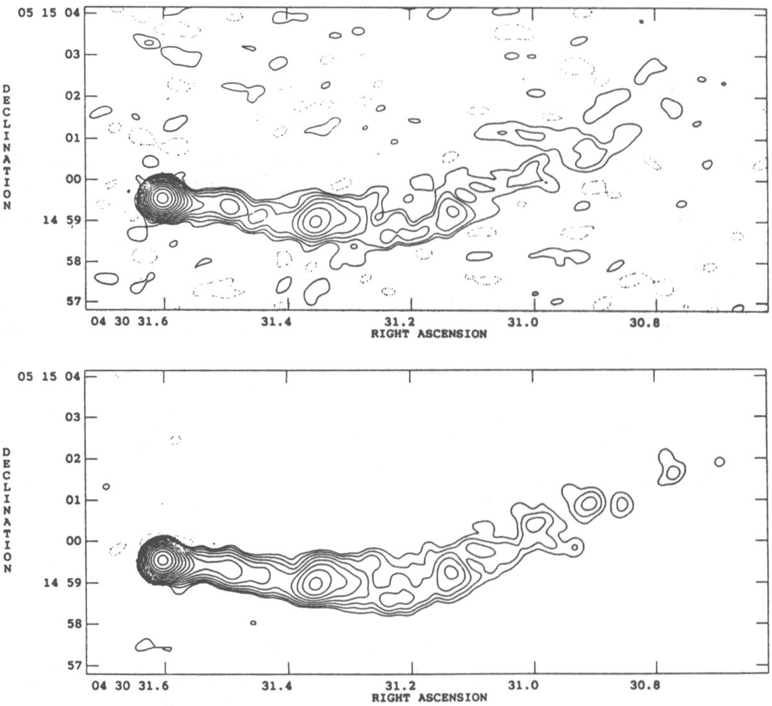


Figure 1. MERLIN 1.67 GHz images of 3C120 from December 1980 (upper) and December 1988 (lower). The contours in the 1980.98 image start at 0.5 mJy beam^{-1} and are then drawn every factor of two above this value. The 1988.92 image is contoured similarly but the lowest one is drawn at 0.25 mJy beam^{-1}.

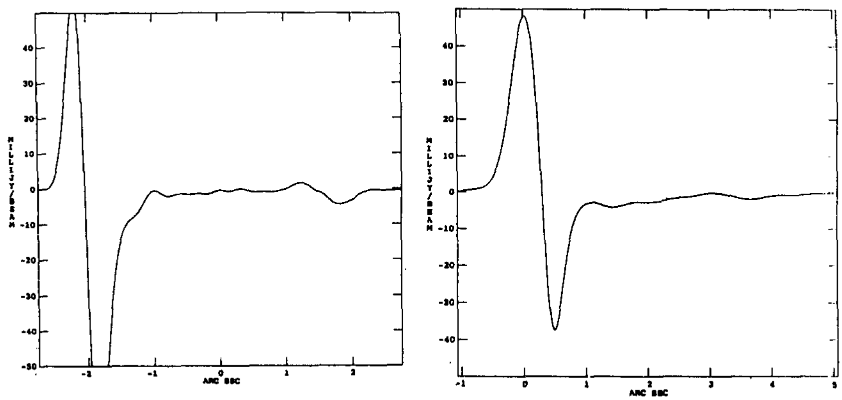
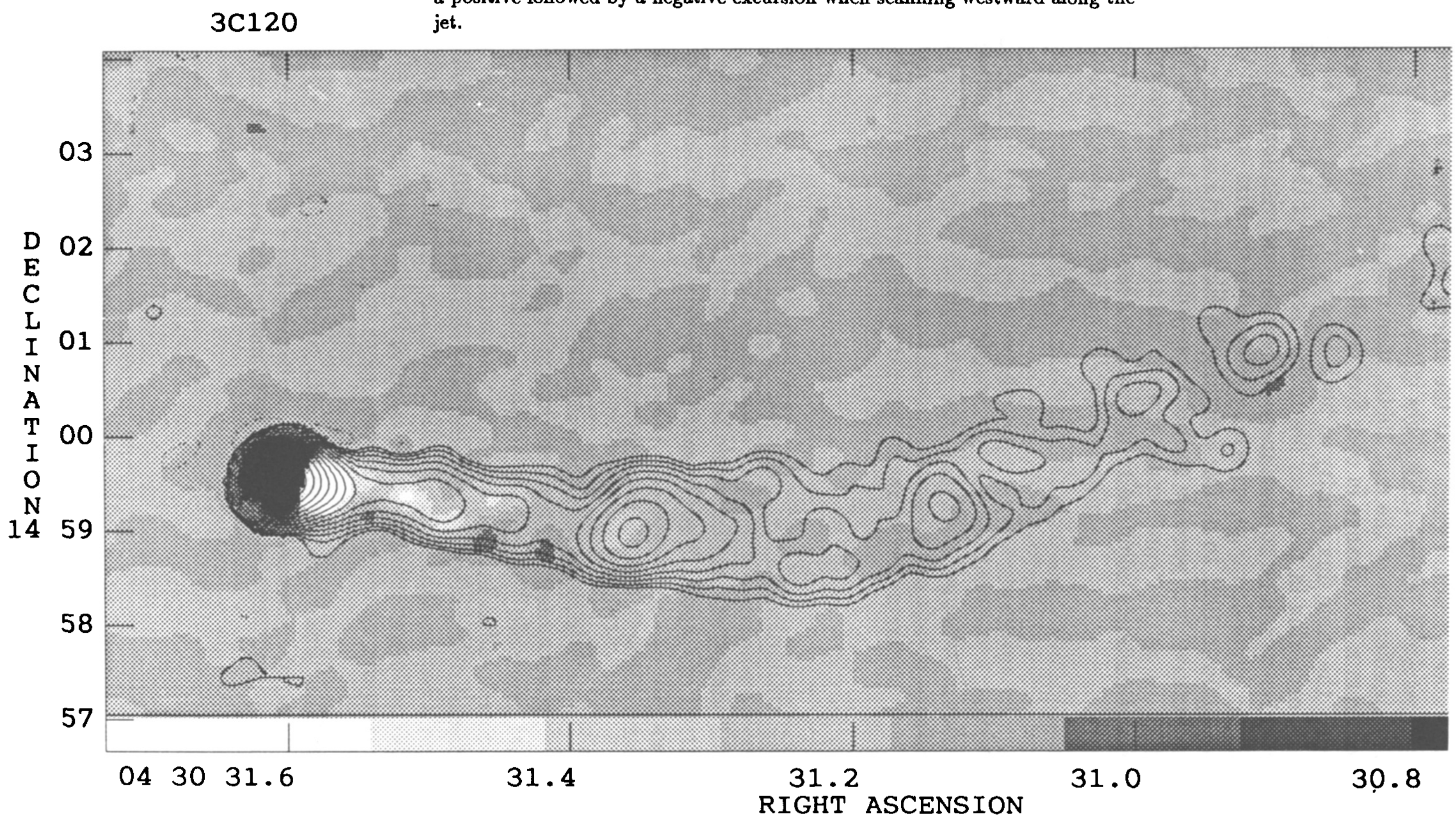


Figure 2 *Right* Profile through the 1988 image and the difference image in position angle -100° i.e. along the ridge line joining the compact central component and the 4 arcsecond knot. *Left* Corresponding profile for the 20 mas simulation.

https://doi.org/10.1017/S0252921100013531 Published online by Cambridge University Press

Figure 3. The difference image in greyscale overlayed on the contours of the 1988 image. Positive–going excursions in the difference image are represented as black, *negative–going* ones as white. An *outward shift* is *characterised* by a positive followed by a negative excursion when scanning westward along the jet.



https://doi.org/10.1017/S0252921100013531 Published online by Cambridge University Press

Craig Walker: I would guess that the difference between these results and my VLA results is related to changes in the core. The flux density of 3C120 dropped significantly in the mid 1980s, then rose again. My two epochs suffered from a 50% change in core flux density while Muxlow happened to see nearly the same flux density at both epochs. Changes were also almost certainly occurring in the inner few milliarcseconds of the jet. The best way to sort this out will be to continue the observations with longer time baselines and higher dynamic range, especially relative to the first epochs. We intend to observe again in 1991 to double our time baseline.
Tom Muxlow: It is possible that changes within what both the VLA and MERLIN see as the "core" could explain the apparent discrepancy. Further epochs are certainly required to resolve this question.