NUMERICAL OBSERVATIONS OF A RESTARTING RADIO JET

DAVID A. CLARKE, JACK O. BURNS, and MICHAEL L. NORMAN

National Center for Supercomputing Applications
University of Illinois at Urbana-Champaign
Champaign, IL 61820, U.S.A.

and

Institute for Astrophysics
The University of New Mexico
Albuquerque, NM 87131, U.S.A

ABSTRACT. An MHD computation of a restarting jet is presented and compared with observations of classical double radio sources. Assuming ideal MHD and an adiabatic equation of state, it is found that a "partial" jet exists for about 25% of the time, and that the terminal hotspot dissipates quickly compared to other physical time scales once the outflow of the jet is terminated.

A numerical simulation of a Mach 6, underdense (density contrast 0.1), axisymmetric, episodic jet with a passive magnetic field in an initially uniform, unmagnetised ambient medium was computed by the 2-D ideal MHD code ZEUS and the synchrotron emissivity code RADIO [see Clarke *et al.* (1989) for descriptions of these codes]. Microphysics such as radiative cooling, viscosity and conductivity are not considered in this calculation. At time $t = t_{\text{flip}}$, the momentum flux of the jet was terminated, and then resumed at a later time $t = t_{\text{flop}}$ (see Figure 1). New properties of a restarting jet revealed by this calculation include:

1. When the outflow is terminated, the hotspot is unconfined, and expands adiabatically in times short compared to t_{flip}. Therefore, hotspots in "jetless" lobes are not observed in these numerical simulations.

2. A "partial" jet exists for about 25% of t_{flop}.

3. Collapse of the ambient and cocoon media onto the symmetry axis after the disappearance of the jet can produce a "jet-like" feature where no "true" jet exists.

4. The bow shock of the restarted jet may be detectable, since the shocked medium is old magnetised jet material with a (perhaps old) relativistic electron population.

If these results are general, the observational consequences are apparent. Hot spots in classical doubles (see Burns *et al.* 1984; Rogora *et al.* 1986) are often found in "jetless" lobes, and "partial" jets are observed in only a few percent of the known classical doubles. In the few known examples of a "partial" jet (*e.g.* 3C 219, 3C 228, and 3C 288), no feature resembling a bow shock at the leading edge of

R. Beck et al. (eds.), Galactic and Intergalactic Magnetic Fields, 435–436.

https://doi.org/10.1017/S0074180900190734 Published online by Cambridge University Press

the jet has been reported. Thus, this simulation is inconsistent with the class of restarting jet scenarios such as the "flip-flop" model (Rudnick and Edgar 1984) and the "relativistic reborn jet" model (Bridle *et al.* 1986). An alternative picture for the classical doubles is the intrinsically bipolar model where a mechanism is required to "hide" one or both of the jets in the source [*e.g.* relativistic beaming (Scheuer and Readhead 1979); passive magnetic field model (Clarke *et al.* 1989)]. A detailed account of this calculation, including a complete set of figures, can be found in Clarke and Burns (1989).

D. A. C. acknowledges the Deutsche Forschungsgemeinschaft for financial support to attend this meeting. This work was partially supported by NSF (USA) grant AST 8611511 to J. O. B. and M. L. N. This work was partially supported by the NCSA NSF (USA) grant AST 87003 and utilised the CRAY X-MP/48 system at the NCSA at the University of Illinois at Urbana-Champaign.

References

Bridle, A. H., Perley, R. A., and Henriksen, R. N. 1986, *A.J.*, **92**, 534.

Burns, J. O., Basart, J. P., DeYoung, D. S., and Ghiglia, D. C. 1984, *Ap. J.*, **283**, 515.

Clarke, D. A., and Burns, J. O. 1989, *in preparation*.

Clarke, D. A., Norman, M. L., and Burns, J. O. 1989, *Ap. J.*, **342** 700.

Rogora, A., Padrielli, L., and de Ruiter, H. R. 1986, *Astron. Astrophys. Supp.*, **64**, 557.

Rudnick, L., and Edgar, B. K. E. 1984, *Ap. J.*, **279**, 74.

Scheuer, P. A. G., and Readhead, A. C. S. 1979, *Nature*, **277**, 182.

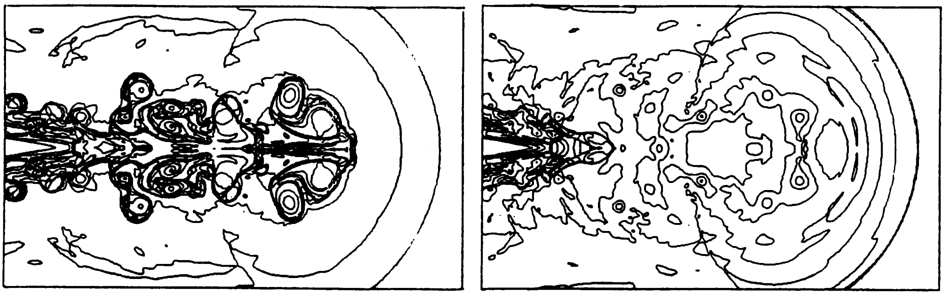

FIGURE 1. Density contours (left) and pressure contours (right) at a time just after $t_{\rm flop}$. Note the new jet boring its way through the old jet material, and the highly diffuse region at the head of the old jet which once was the terminal hotspot.

https://doi.org/10.1017/S0074180900190734 Published online by Cambridge University Press