VIEWING ANGLE AND THE APPEARANCE OF SUPERLUMINAL JETS

H. D. ALLER, M. F. ALLER, P. A. HUGHES, A. MIODUSZEWSKI
University of Michigan – Ann Arbor, MI, 48109-1090

1. Evidence for Changes in Angle of Jet Orientation

The time history of BL Lacertae has shown clear evidence of changes in jet orientation both in the plane of the sky and in the angle to the line of sight (see Figure 1). Models based on transverse shocks in a relativistic flow quantitatively fit the polarization and flux density data well and permit one to determine parameters of the flow such as the bulk Lorentz factor and the angle of the flow to the line of sight (Hughes, Aller and Aller 1989). The orientation of the jet flow to the line of sight changed by approximately 6° between the early 1980 bursts and one in 1991. There have been comparable changes in the orientation of the jet on the plane of the sky. Such changes in jet orientation may be due to a helical flow pattern arising from precession or instability.

2. Simulation Results

The appearance of a jet with relativistic flow speed can be strongly influenced by the viewing angle. We have carried out jet simulations using a hydrodynamical code which admits relativistic velocities. The observed intensity is computed by solving the equation of transfer along the lines of sight using an algorithm which accounts for both the opacity and relativistic effects in the emitting region. Figure 2 shows the case of a collimated flow for which the inflow velocity has been modulated between a Lorentz factor of 1 and 10. When viewed at a large angle, the full lateral extent of the jet is evident, but when observed at an angle of 10° only the inner core of the flow is apparent in the intensity maps. The major cause of this difference is Doppler boosting, and this example underscores the fact that only a small fraction of the true jet flow may be apparent in VLBI maps of

R. Ekers et al. (eds.), Extragalactic Radio Sources, 437–438.

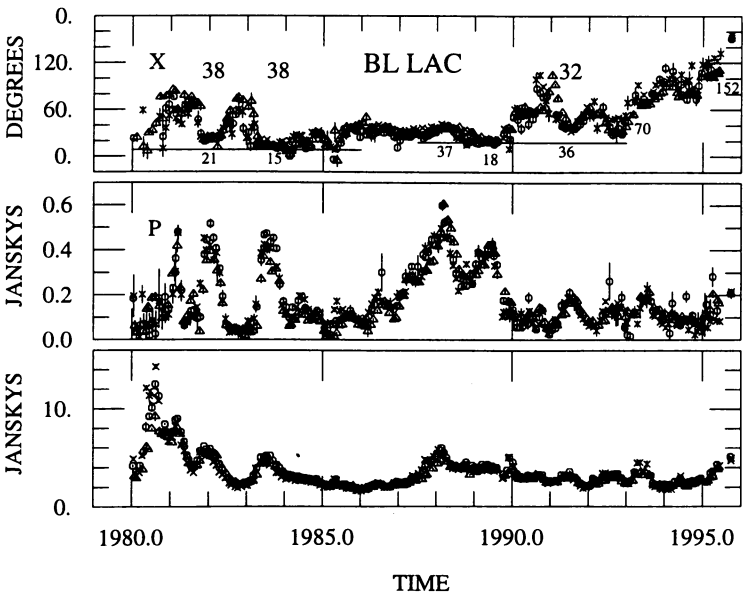

Figure 1. Monthly averages of total flux density and polarization of BL Lac. The derived angles to the line of sight for three bursts are given by the larger numbers. The smaller numbers give the average PA during each burst. The horizontal lines are the observed direction of the jet seen by VLBI (Mutel *et al.* 1990, 1994).

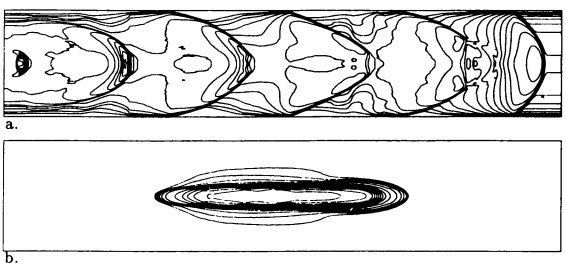

Figure 2. Intensity distribution derived for a relativistic velocity-modulated jet, observed at angles of a. 90°, and b. 10° to the line of sight.

these objects. We give special thanks to Comer Duncan, and we thank the NSF for partial support (AST-9421979).

References

Hughes, P. A., Aller, H. D. and Aller, M. F. 1989, *ApJ*, **341**, 68.
Mutel, R. L., Phillips, R. B., Bumei Su, and Bucciferro, R. R. 1990, *ApJ*, **352**, 81.
Mutel, R. L., Denn, G. R. and Dryer, M. J. 1994, *Proc. of the NRAO Workshop on Compact Extragalactic Radio Sources*, (NRAO: Socorro), ed. Zensus and Kellerman, p. 191.