IAU Colloquium 164: Radio Emission from Galactic and Extragalactic Compact Sources
ASP Conference Series, Vol. 144, 1998
J. A. Zensus, G. B. Taylor, & J. M. Wrobel (eds.)

Very Long Baseline Polarimetry of BL Lac

G. R. Denn & R. L. Mutel
University of Iowa, Iowa City, IA 52242, U.S.A.

Abstract. We have made polarization sensitive maps of BL Lac with the VLBA at 15, 22, and 43 GHz at seven epochs from 1995.42 to 1997.16. Three new superluminal components (S8, S9, and S10) have been identified, each having a unique signature in trajectory and polarization characteristics.

1. Introduction

BL Lacertae is a low redshift (z=0.069), highly variable blazar which has been extensively monitored at many wavelengths, including single dish radio measurements (Aller, Hughes, & Aller, these Proceedings, p. 167) and with VLBI (Mutel et al. 1990). BL Lac exhibits a core-jet morphology and has ejected several superluminal components, effectively modeled as planar shocks embedded within a relativistic flow (e.g., Hughes, Aller, & Aller 1989). These ejections accompany dramatic increases in total and polarized flux, and occasionally large shifts in integrated polarization angle are also seen.

2. VLBA Monitoring

Using the VLBA at several wavelengths, we have observed the emergence of three new linearly polarized superluminal components (S8, S9, and S10) between epochs 1994.73 and 1997.16. For all three components the polarization position angle varies as the component separates from the core. The position angle at each epoch for all components was the same within observational uncertainty at 15, 22, and 43 GHz, indicating little (RM<500) internal rotation measure variation in the source. Furthermore, the core-component separation for all components was independent of wavelength at all epochs, in contrast to the prediction of Königl's (1981) cylinder jet model.

Component S8 appears to be following a curved trajectory with a varying apparent speed between approximately $1 \lesssim \beta \lesssim 4$. Component S9 was first noticed as a core elongation on a 22 GHz map at epoch 1995.97, and as a distinct component at 1996.75; a two epoch measurement implies $\beta_{app} \sim 7$, but it appears to have stalled between 1996.97 and 1997.16. The trajectory of S9 appears to be nearly radial. Component S10 is near the core (0.3 mas) and is distinct only on two 43 GHz maps (see Figure 1a). Formal fits to the position of S10 show non-radial motion to the southeast.

3. Helical Model for BL Lac

The steady rotation of integrated position angle over this time (Aller, Hughes, & Aller, these Proceedings, p. 167) matches the polarization vector rotation observed in component S8. Preliminary calculations and comparison to models of polarized helical jets (e.g., Gómez et al. 1994) suggest that the trajectory, variation in apparent speed, and polarization rotation can be explained by a planar shock traversing a relativistic helical flow. Blandford & Königl (1979) have shown that a relativistically convected planar shock can produce rotations of this nature; we are currently investigating the polarization properties of a planar shock traversing a helical trajectory.

Although VLBI monitoring of BL Lac during the 1980's (Mutel et al. 1990) did not show any indication of non-radial motion of components, this may have been a result of inadequate spatial resolution, since all observations were done at 10.7 GHz or lower. Modeling of BL Lac (Aller, Hughes, & Aller, these Proceedings, p. 167) indicates that the flow direction of BL Lac has taken a dramatic swing to approximately position angle 210° at epoch 1996.6. This is consistent with the our VLBA maps, which show components S9 and S10 near this position angle.

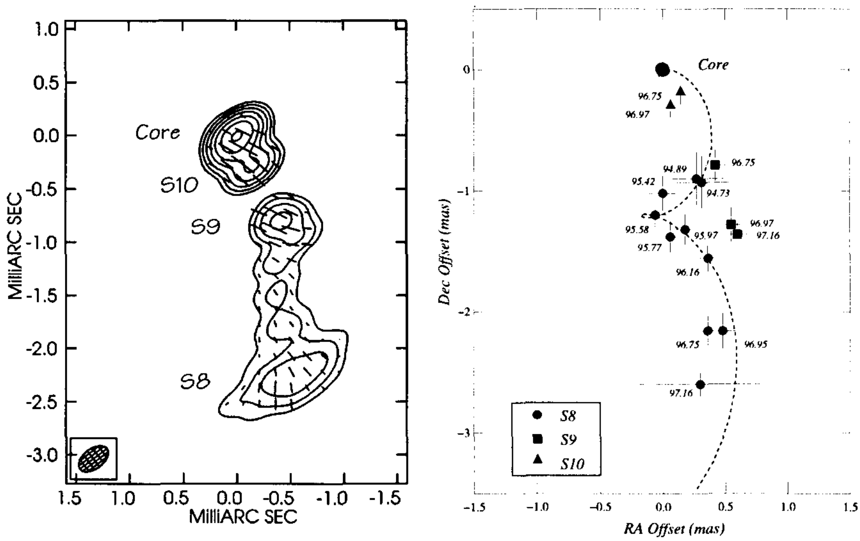

Figure 1. a) A 43 GHz polarization map of BL Lac at epoch 1996.75. b) Component positions at various epochs with Hardee's (1987) adiabatic helical model fit. The angle from the line-of-sight to the helical axis is 10°, the helical opening angle is 2.2 degrees, and the Lorentz factor is 2.8.

Acknowledgments. The National Radio Astronomy Observatory is a facility of the National Science Foundation, operated under a cooperative agreement by Associated Universities, Inc.

References

Blandford, R. D., & Königl, A. 1979. *ApJ*, **232**, 34–48.
Gómez, J. L., et al. 1994. *A&A*, **292**, 33–44.
Hardee, P. E. 1987. *ApJ*, **313**, 607–622.
Hughes, P. A., Aller, H. D., & Aller, M. F. 1989. *ApJ*, **341**, 68–79.
Königl, A. 1981. *ApJ*, **243**, 700–709.
Mutel, R. L., et al. 1990. *ApJ*, **352**, 81–95.