BL Lacertae's Compact Variations, 1980-86: A Polarized, Superluminal Challenge.

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BL Lac shows tightly correlated events in flux density and polarization. When the time scale slows enough for VLBI observations to track them, moving features which mimic piston-driven shocks seem to carry the disturbances. Evidence for BL Lac's shocks may ameliorate the difficulties posed by the excessive incidence of superluminal motion among core objects; superluminal motion may arise from any number of conditions combining shocks and optical depth, not just real jet or real component motions.

Circa 1980, the most popular world view for explaining bright, variable compact sources asserted that Little Sources were carefully aimed Big Sources, such that real bulk motions enhanced by many times the emission and shortened the time scale for variations, compared to those seen by a co-mover. Superluminality was seen as vindication by the view's boosters; the old light-travel-time canard was relegated to predicting mimimum source sizes following outbursts.

BL Lac's new era of powerful variations began in 1980, characterized particularly by its wild, intractable polarization rotations. Our earliest results (Mutel, Aller, Phillips 1980) indicated a source size larger than ct, and Phillips and Mutel (1982) substantiated components that implied a speed of 5c.

It was superluminal, but just what did that mean any longer? By 1983, VLBI investigators were beginning to pile up a surfeit of superluminal sources. BL Lac had begun a second career by showing two nearly identical polarization events - events which seemed to be carried by the moving (5c) features that faded before reaching a dozen or so light years from their spot of origin. Both events showed a de-rotated p.a. for fractional linear polarization P (E-vector) near the VLBI channel of motion (25 and 20 degrees versus 18 for the channel); the second P-event showed convincing evidence for apparent slowing and stagnation of the moving component. Let us review why we think the moving features are the carriers of P. First, the northern bright spot is always a feature in any map, has a flat spectrum, and can even be modeled as constant in strength (except when a new eruption is confused with it.) It always remains when BL Lac returns to P-quiescence. Finally, the fading of the moving VLBI features corresponds precisely with the fading of P-emission.

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The distinctive first P-event with B-field transverse to motion was sufficient to inspire Hughes, Aller, and Aller (1985) to investigate piston-shock models for intensifying B-fields and emission. One remarkable solution to these models shows a shock beginning to exhibit polarization after about 0.15 y; the scale for the driving piston's life is such that emission peaks at about 0.4 y and fades quickly (all in our frame.) This solution is a replica of the two P-events; small changes in optical depth up and down the jet might easily cause the perceived core position to move, leading to apparent decelerations in feature motions as we saw in 1984. Hughes (elsewhere in this volume) has synthesized brightness distributions for the 1982-84 era which show the general features of our VLBI maps, as well.

What is it that BL Lac offers us? Two lessons: one, superluminal features don't always spring full-blown like cannonballs from a core, but can be more ephemeral things that reach prominence well away from their apparent origin (the source core); two, all the bright features in variable compact sources should be viewed as places of localized high optical depth, whose location may wander not entirely in step with bulk flow. Future observations truly need polarization content and astrometric referencing to resolve the question of feature deceleration; BL Lac has already dropped a strong hint that superluminality is not always composed of cannonballs.

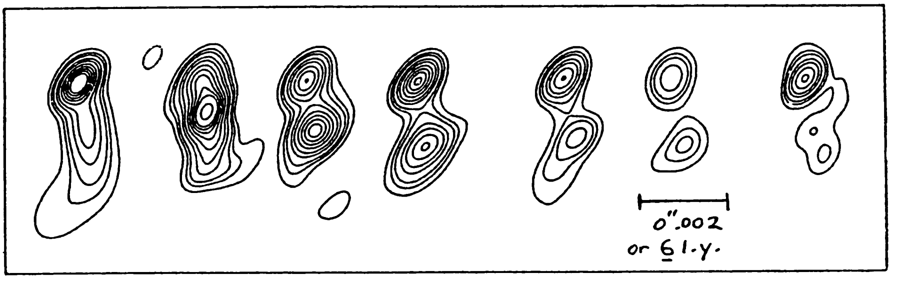

Fig. 1. Montage of BL Lac at 10.7 GHz spanning 1983.1-1985.3. This is the second of two P-events, and shows the apparent stagnation of the southern feature. Time scale is linear.

REFERENCES

Hughes, P.A., Aller, H.D., and Aller, M.F., 1985, Ap.J. **298**, 301.
Mutel, R.L., Aller, H.D., and Phillips, R.B., 1981, Nature **249**, 236.
Phillips, R.B., and Mutel, R.L., 1982, Ap.J. **257**, L19.

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