EVIDENCE FOR RELATIVISTIC MOTION IN THE MILLISECOND STRUCTURE OF BL Lac

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After several years of relative quiescence, the flux of BL Lac has increased dramatically at centimeter wavelength, starting about epoch 1979.9 (Fig. 1). We have begun a series of VLBI observations to monitor the milliarcsecond structure at λ6 and λ2.8 cm wavelengths, using a five element VLBI array consisting of telescopes at Bonn, West Germany; Westford, MA; Green Bank, WV; Ft. Davis, TX; and Owens Valley, CA. The first two observations, in 1980 May and September, were at 5 GHz and were not of sufficient resolution to distinguish individual components in the source (Mutel, Phillips and Aller 1981). They did show, however, that the source was highly elongated along position angle ~ 10° and was expanding that axis with a velocity of ~4 c. The position angle is the same as several previous VLBI observations of this source, both during quiet periods and during previous flux outbursts (Pearson and Readhead 1981; Shaffer 1978 and references therein).

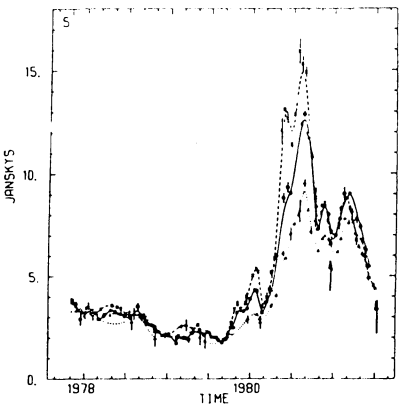

Fig. 1. Flux versus time at λ6 cm (...), λ4 cm (—), and λ2 cm (---).

In order to increase the angular resolution of the observations, a frequency of 10.6 GHz was used during observations in 1980 December and 1981 June. The hybrid maps are shown in Fig. 2a. Again, the source was found to be elongated along a position angle ~ 10°, but with increased resolution separate components became apparent. Fig. 2b shows one-dimensional profiles of peak brightness along p.a. of 10° for both epochs. We arbitrarily aligned the brightest component to be coincident between epochs, but since absolute phase is not measured, the true registration between the maps is unknown.

A comparison of the source size at both epochs with the flux history of Fig. 1 shows immediately that the components are too far apart to have been causally related unless (1) there was a coincidental

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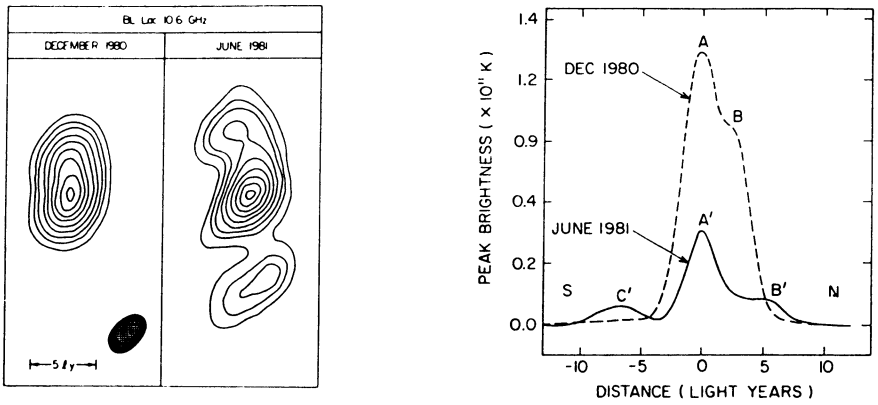

(a) (b)

Fig. 2. Hybrid maps (a) and one dimensional profiles (b) through position angle 10° for epochs 1980.44 and 1980.93.

brightening of unrelated components ("Christmas tree" model) or (2) relativistic time dilation is responsible. The former explanation seems unlikely, especially considering the rather long period of quiescence prior to the current flux outburst.

For a relativistically moving source, the 'speed-up' of events occurring in the co-moving frame as seen by the distant observer scales as the Doppler factor γ. For the 1980 December map we derive a $\gamma \sim 4$ by comparing the apparent source size (~ 4 light-years) with ~ 1 year since the beginning of the flux outburst. A comparison of the 1980 December map with the 1981 June map shows that another component ('C') has appeared about 6.8 light-years south of component A. Furthermore, the northerly component ('B') has become more complex and has extended to ~ 5.5 light-years along a position angle of 10°. In both cases, if we assume expansion from the strong central A component, relativistic motions with a Doppler factor of $\gamma \sim 5$-7 are necessary. Alternatively, if we assume component B to be the central source, the southerly component (C) would require a $\gamma \sim 20$ to have been emitted from position 'B' ≤ 6 months prior to being seen (June 1981).

It is clear that further VLBI monitoring of the structure of BL Lac will be necessary to unambiguously determine the motion of individual components and hence the detailed dynamics of the source.

References

Mutel, R. L., Phillips, R. B., and Aller, H. 1981, submitted to Nature.
Pearson, T. J., and Readhead, A. C. S. 1981, Ap. J., in press.
Shaffer, D. B. in Pittsburgh Conference on BL Objects, U. of Pittsburgh, PA, 1978.

BACKER: Is the appearance of component "C" only in the June 1981 map a dynamic range effect (since the June 1981 flux was about a factor of two lower than December 1980)?

MUTEL: No, the lack of a third component in December 1980 is evident on the profile plot (Fig. 2b).