THE RADIO POLARIZATION OF BL LACERTAE: SHOCKS IN A JET +

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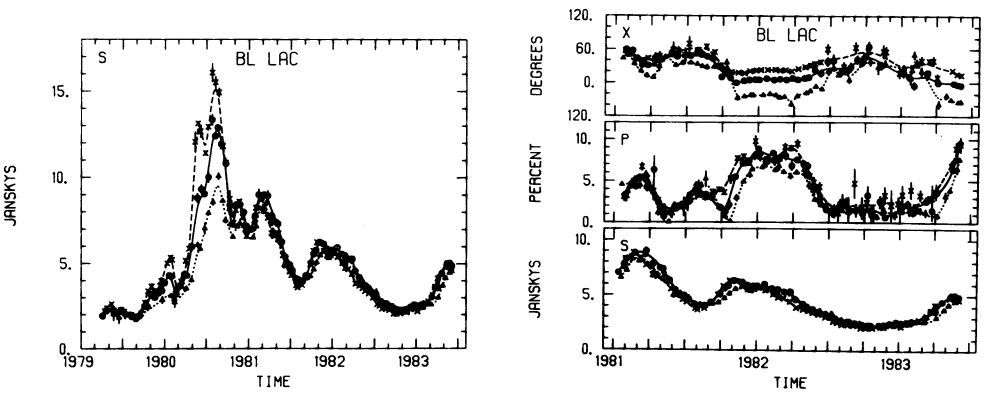
Abstract: The behavior of the linear polarization of BL Lacertae during the recent series of radio bursts indicates the presence of Faraday rotation in the vicinity of the source and the formation of an axial compression in the radio jet.

In the past four years BL Lacertae has exhibited a series of radio outbursts (Figure 1a) which were preceded by a three year period of relative inactivity. During these bursts the source has exhibited apparent superluminal motions along a position angle of 10° (Phillips and Mutel 1982, Phillips 1983); and the polarization characteristics have changed dramatically. This paper describes the evidence for Faraday rotation and the behavior of the intrinsic polarization position angle since 1980 based upon data obtained with the automated University of Michigan 26-meter radio telescope.



a) b)

Figure 1: Flux density (a) and polarization (b) of BL Lacertae: Two-week averages of the data at 4.8,8.0 and 14.5 are indicated by Δ, o, and x.

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R. Fanti et al. (eds.), VLBI and Compact Radio Sources, 119–120.

Throughout the bursts in 1980 the degree of polarization was relatively low (less than 5 percent) and the source exhibited rapid polarization variations including the position-angle rotation phenomenon (Aller, Hodge, and Aller 1981). In the bursts since 1980 the degree of polarization has been systematically higher and the position angles have been relatively stable (Figure 1b). We interpret the increased degree of polarization in the later bursts as due to an increased degree of order of the magnetic field as the emitting region has evolved. In the burst which started in late 1981, the degree of polarization increased dramatically, and the polarization position angles at the three frequencies separated into a pattern characteristic of Faraday rotation. The derived rotation measures before and during the burst were -103 and -234 rad.m^{-2} respectively. The rapid change of -131 rad.m^{-2} in the rotation measure is most easily accounted for by a small cloud (N_e = 1 cm^{-3} and B = 2 x 10^{-4} Gauss) in the vicinity of BL Lacertae's radio emitting region. Placing the rotation in our galaxy or within the emitting region gives problems with the small angular size of the source or with the constant value of the rotation measure during the evolution of the burst. As the burst died out, the polarizations appear to have resumed their previous values; but with the appearance of a new burst in 1983, the pattern is repeating. The rotation measure during the 1983 burst is derived to be -255 rad.m^{-2}.

The intrinsic polarization position angles during the late 1981 burst were in the range of 23 to 28 degrees and subtraction of the pre-burst polarized flux places these values in the range of 15 to 20 degrees. For the 1983 burst the observed IPA is 21 degrees, and removal of previous polarized emission yields a value of 18 degrees. In both bursts the polarization data indicate an orientation of the magnetic field in the emitting region which is nearly perpendicular to the "jet" observed by VLBI. The orientation of the magnetic field and the high degrees of polarization during the bursts suggest the formation of an axial compression (or shock) down the jet which results in the reacceleration of the emitting particles and the appearance of a new source component. VLBI observations (Mutel et al. 1984) show the appearance of a new source component coincident with the late 1981 flux density event, and we predict that future VLBI observations will detect a new source component appearing in 1983. The polarization data, together with the VLBI observations, furnish strong evidence for substantial reacceleration of emitting particles within the jet-like emitting regions of extragalactic variable sources. This has important implications for not only the centimeter variability phenomenon but may also have application to low frequency variable sources. This work was supported in part by the National Science Foundation Grant No. AST 8021250 A01.

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