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Serendipitous VLBI Observations of Intraday Variability in the BL Lac Objects 1334−127, 2131−021, and 2155−152

P. Yu. Kochanev
Sternberg Astronomical Institute, 119899 Moscow, Russia

D. C. Gabuzda
Astro Space Center, Lebedev Physical Institute, 117924 Moscow, Russia

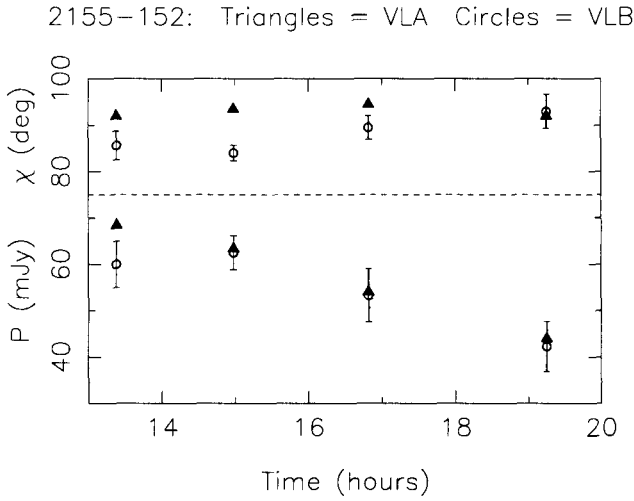
Abstract. Global $\lambda = 6$ cm VLBI polarization observations of intraday variability in the three BL Lacertae objects 1334–127, 2131–021, and 2155–152 are analyzed. Integrated VLA measurements during the VLBI observations show that although there were no substantial total intensity variations, the polarizations for these three sources varied significantly during the VLBI experiment. The VLBI data were divided into 2-3 hour segments in order to search for corresponding rapid variability in the VLBI polarization structure. Our analysis shows that the VLA polarization variability in 2155–152 and 2131–021 is present in the VLBI data (i. e., it occurred on mas scales), but this is not the case for 1334–127.

One of the main questions in the physics of compact extragalactic radio sources is whether very rapid (intraday) variations are extrinsic (e. g., due to refraction in the interstellar medium) or intrinsic. One natural "intrinsic" explanation is that two or more variable polarized components contribute to the integrated measurements. Large-amplitude and rapid integrated variations can occur, for instance, if one of two comparably strong components polarized roughly orthogonal to each other varies. One component might be identified with a relativistic shock that varies as it propagates down a turbulent jet (Qian et al. 1991; Wagner et al. 1996): the rapidity of the variations corresponds to the thinness of the shock structure transverse to the direction of propagation. Our VLBI polarization observations of 2155–152 reveal precisely this sort of structure, with one polarized mas-scale component constant while the polarized flux of the other decreases by roughly a factor of two over a time interval of about six hours. This is fairly strong evidence that at least some intraday variability events are intrinsic to the sources.

In March 1992, we obtained global VLBI polarization observations of eighteen BL Laceratae objects. The phased VLA was used as one of the VLBI elements, so that we could use the VLA data to monitor the integrated total intensity (I) and polarization (P) during the VLBI run. There was no evidence for I variability in any of the sources, but there were significant P variations in three sources: 1334–127, 2131–021, and 2155–152. We therefore divided the VLBI P data for each of these three sources into groups in time lasting 2–3 hours, during which the VLA P was roughly constant. We then conducted independent P imaging and model fitting for each group of scans for all three sources. The results are summarized below.

1334–127 Though there is some evidence for variability in the VLBI P data, there is no obvious relation between the polarized fluxes and polarization position angles χ for the VLBI and VLA data. Thus, if the VLA variations are real, they occurred on scales larger than those sampled by our VLBI array.

2131–021 In this case, it is clear that the VLA variations occurred on mas scales, in the VLBI core, which was the only VLBI component detected in polarization.



2155–152 Two well-separated components were detected in polarization. The P of one of these components was constant, while the polarized flux of the other decreased by about a factor of two on a timescale of about six hours. The figure shows that the vector sum of the P for the two VLBI components match the integrated VLA P measurements extremely well. This makes it most likely that the variations in the VLA data in 2155–152 were intrinsic, since they occurred on mas scales, in only one of two clearly-detected VLBI components.

The observed rapid variability in two of the three sources considered here—2131–021 and 2155–152—occurred on milliarcsecond scales. This was also the case for 0917+624 (Gabuzda & Kochanev, these Proceedings, p. 265) and, earlier, in 0735+178 (Gabuzda, Wardle, & Roberts 1989). In the case of 0735+178, 0917+624, and 2131–021, it is not possible to rule out an extrinsic mechanism for the variations, since only one VLBI component was detected in polarization. For 2155–152, however, we clearly detected polarization from two VLBI components, one of which varied while the other remained constant. This is fairly strong evidence that the intraday variability in 2155–152 was intrinsic. In order for this type of behavior to be caused by scintillation, one component would have to be much more compact than the other: we could then have a situation where the compact component varied due to scintillation in the interstellar medium, while the other component was too large to scintillate.

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