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Multi-Epoch VLBA Observations of γ-Ray Bright Blazars

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Abstract. We have investigated the sub-milliarcsecond scale structure of 41 γ-ray bright blazars with the VLBA at frequencies of 22, 43, and occasionally 8.4 GHz. All of the blazars have dominant, unresolved (less than 0.1 to 0.2 milliarcsec) cores, with the exception of 0954+556, which has no structure apparent on scales less than about 1 milliarcsec. Some have prominent jets, others show only faint secondary components or no non-core structure at all. Apparent velocities have been measured for 13 sources. These range from no detected motion to > 25c.

1. Introduction

We have been monitoring the sub-milliarcsecond scale structure of 41 γ-ray bright blazars at frequencies of 22, 43, and occasionally 8.4 GHz, with the VLBA. Prior to 1995, all observations were with the Mk 2 (2 MHz bandwidth) recording system, and since then with the VLBA system using either 4 or 8 8-MHz wide channels. Most observations were in "snapshot" mode, with 3 to 7 scans of length 6 to 14 minutes each. The observations were analyzed by performing the *a priori* calibration and fringe fitting within the AIPS software package provided by NRAO followed by self-calibration and imaging using the Caltech package Difmap. The dynamic range of the image depends on factors such as u-v coverage (after data editing), weather and receiver health at individual antennas, and the flux density of the source. Typically, 200 : 1 peak-to-noise was achieved, to within a factor of about 2, except in special cases. Unbelievable features are apparent on the images at 2-3 times the noise level.

Images of the sources in the sample are presented in **http://bu-ast.bu.edu/~mattox/agn-catalogs.html**.

2. Discussion of Selected Sources

The following sources are so dominated by the core that our images with dynamic ranges of order 100:1 do not reveal significant (i. e., more than 3 times the noise or seen at more than one epoch) non-core components: 0235+164, 0454–234, 1101+384 (Mrk 421), and 1739+522. Sources with prominent jets include 0202+149, 0219+428 (3C 66A), 0234+285, 0336–019 (CTA 26), 0440–003 (NRAO 190), 0804+499, 0827+243, 3C 273, 3C 279, 1510–089, 1611+343, 1622–297, 1633+382, 2230+114 (CTA 102), and 3C 454.3. Of these, some of the jets (e. g., 0234+285, 1510–089, and 1611+343) appear rather broad at high frequencies relative to the more narrow jets typically seen at 5 GHz. Sources showing

Table 1. Apparent superluminal velocities of selected sources.

Source	Redshift	pc / mas	v/c
0202+149	0.833	7.5	-
0219+428 (3C 66A)	0.444	5.7	25
0234+285	1.213	8.3	0
0336−019 (CTA 26)	0.852	7.5	14
0420−014	0.915	7.7	0
0440−013 (NRAO 190)	0.844	7.5	11
0458−020	2.286	8.7	9
0827+243	2.046	8.7	18
0829+046	0.18	3.1	23
0917+449	2.180	8.7	9
1127−145	1.187	8.3	6
1510−089	0.360	5.0	9
1606+106	1.23	8.3	-
1611+343	1.401	8.5	13
1908−201	?	-	-
2251+158 (3C 454.3)	0.851	7.5	13

significant non-core components that are not sufficient to define a jet are 0420–004, 0446+112, 0458–020, 0716+714, 1730–130, and 1741–038. Observations with higher dynamic range than these "snapshots" might be able to detect an underlying jet in such sources. As an example, we represent the results for the object where one can expect a connection between γ-ray variability and a radio structure of a jet.

NRAO 190: A γ-ray flare was observed in the flat-spectrum QSO NRAO 190 by EGRET during the period 9–29 Aug 1994 (McGlynn et al. 1997). We have analyzed the VLBA data at 22 and 43 GHz of this source at five epochs after the γ-ray flare (Feb 95, Jun 95, May 96, Aug 96 and Nov 96). There is an apparently stationary component 1.3 mas from the compact core, with an essentially constant flux of about 0.04 Jy. A component appeared near the core and moved toward the stationary component with an apparent superluminal speed $11c$ (for $H_0 = 65$ and $q_0 = 0.1$). The fluxes of both the core and the knot are variable by a factor ~ 2. Extrapolation of the superluminal motion corresponds to a time of ejection within about one month of the γ-ray flare in NRAO 190.

Table 1 represents the summary of measured superluminal speeds in the jets for the subsample of γ-ray bright blazars whose images are analyzed in this work. Column 4 gives the apparent speed for $H_0 = 65$ km s^{-1}Mpc^{-1} and $q_0 = 0.1$.

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References

McGlynn, T. A., et al. 1997. *ApJ*, **481**, 625–632.