Linear Polarization as a Probe of Gamma-Ray-Flaring Blazar Jets

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ABSTRACT

We are monitoring the radio-band linear polarization from a sample of gamma-ray-flaring blazars in order to identify conditions in the jet responsible for the generation of the high energy emission and to test whether shocks play a role.

Overview

As part of a cycle 2 *Fermi* project we are monitoring the temporal evolution in total flux density and in linear polarization (hereafter LP) of approximately 30 gamma-ray-bright AGN using the University of Michigan (UMRAO) 26-meter radio telescope operating at centimeter band (4.8, 8,0, and 14.5 GHz) in order to identify changes in LP within the radio jet associated with gamma-ray flaring. Past work found a temporal association in activity across bands. At radio wavelengths flaring is generally attributed to the development of shocks in the jet flow; with the passage of these shocks, there is a compression of the magnetic field within the radio jet whose signature is a swing in the position angle of the electric vector of the polarized emission (EVPA) and an increase in the fractional linear polarization. The goal of this project is to identify jet conditions responsible for the generation of the gamma-ray emission and to test whether shocks play a role as suggested in earlier work (Jorstad et al. 2001).

The Source Sample

Our source sample is identified in Table 1. Objects were selected based on the following criteria:

1) inclusion in the high confidence list in the Abdo et al. (2009) 3-month catalogue based on early Fermi measurements, or identified as bright in subsequent ATels; these objects are expected to be gamma-ray bright during *Fermi* cycle 2
2) radio band total flux density >1 Jy; ensures adequate signal-to-noise in the LP data for tracking variability.
3) Membership in the MOJAVE 15 GHz survey (e.g. Lister et al. 2009); imaging data provides information on the contributions from individual components at selected epochs.

Objects designated in gold have highest priority based on their current gamma ray fluxes. Several sample members are new to our program; others have been observed by UMRAO for many years.

We also observe sources on the LAT Monitored Source List not included in Table 1 as time permits, e.g. 1730-130 (NRAO 530). See Figure 3.

Table 1: Program Sources

0048-097	3C 84	0805-077	1308+326	OT 081	CTA 102
0109+224	NRAO 190	OJ 287	1502+106	1849+670	3C 454.3
DA 55	0454-234	0917+449	1508-055	1908-201	
0215+015	0528+134	1127-145	1510-089	2023-077	
3C 66A	0716+714	3C 273	1633+382	BL Lac	
0235+164	0727-115	3C 279	1717+178	2201+171	

Example Behavior Patterns of LP variability

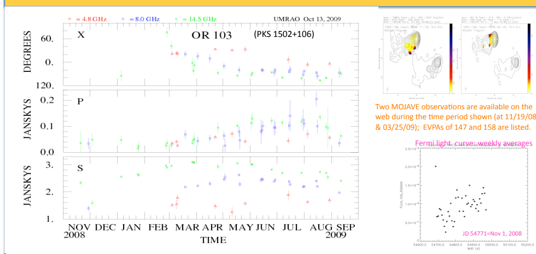

Figure 1. Daily averages of total flux density and LP illustrating variability since intensive monitoring commenced in March 2009. Note the outburst in polarized flux, and the systematic change in EVPA (top panel) which tracks at 14.5 and 8 GHz.

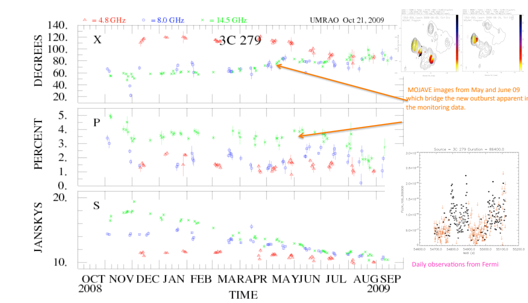

Figure 2. Example of radio band variability in a source with complex parsec-scale structure. The source has remained active in the gamma-ray band since launch. The overall activity in the two bands is correlated, but specific flares in total flux density or LP do not match in time. Cm-band outbursts in the 1980s were successfully modeled with a transverse shock model (Hughes, Aller, & Aller 1991)

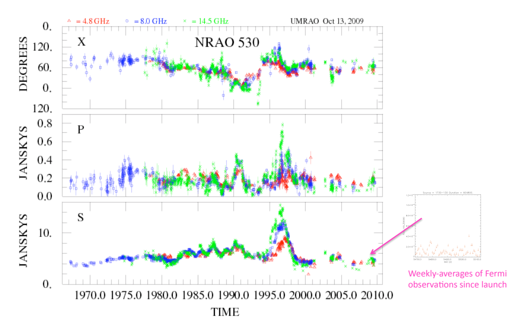

Figure 3. Example of a LAT-monitored source which was bright during the EGRET era (1990s) but for which no flaring has been detected by Fermi. No large radio band flares in either total flux or polarization have occurred during the past decade.

Observing Strategy

• Exploratory measurements began in March, 2009 to provide baseline measurements on sources new to the UMRAO monitoring program. Observation of the complete sample started in August.
• Two observations weekly at 14.5 GHz, and one observation weekly at 8 and 4.8 GHz are planned for flaring objects throughout *Fermi* Cycle 2. This sampling is matched to the expected LP variability time scale. Sampling will be adjusted to follow more rapid variability if found in some objects.
• Since only 20-25 sources can be observed in a 24 hour period, the most active sample members will be selected based on current gamma-ray activity.
• Integrations of 30-40 minutes are required per source for LP. Calibrators are observed every 1-2 hours for antenna gain and pointing, and for verifying the instrumental polarization

Summary of Early Program Results

1. We have already found LP variations in several sources temporally associated with gamma ray flaring (0727-115, 0805-077, 3C 279, 1502+106, & 1510-089). The time scales are typically several weeks to a few months in duration. Several of these events will be modeled using new radiative transfer code to be developed allowing for oblique shocks; this work will use MOJAVE data to constrain geometrical model parameters (shock orientation relative to flow direction).
2. Two very bright EGRET sources on the LAT bright source list (0528+134 & NRAO 530) have (so far) not exhibited flaring in either the radio band or in the gamma-ray domain. This is as expected if the activity is broad band and the same particles are responsible for the radio emission in the jet and for the gamma-ray emission.
3. Some sources exhibiting gamma-ray flaring have not shown large amplitude changes in either total flux or in polarized flux (e.g. NRAO 190). We do not know yet whether this is because of frequency-dependent time delays across the bands, the masking of variability in the UMRAO source-integrated measurements due to competing, independently evolving components, or whether more than one scenario is required to explain the origin of the high energy emission.

References

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