15 GHz Monitoring of Gamma-ray Blazars with the OVRO 40 Meter Telescope in Support of *Fermi*

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Abstract. Since mid-2007, we have been monitoring $\sim$1200 sources at 15 GHz with the 40 M Telescope at the Owens Valley Radio Observatory. Our sample, mostly blazars, is monitored at least twice per week, yielding densely-sampled light curves. A large fraction of the sources in our sample exhibit significant variation in 15 GHz flux density, enabling variability studies and cross-correlations with other bands. Additionally, many have been detected by the *Fermi* Gamma-ray Space Telescope. We compare our data with gamma-ray data from *Fermi* and find a statistically significant flux density correlation after accounting for red shift and selection biases using a new Monte Carlo method. The OVRO program is a part of the F-GAMMA project, which also obtains monthly 2.6 – 270 GHz radio spectra for a smaller, overlapping blazar sample.

INTRODUCTION AND PROGRAM DESCRIPTION

The extragalactic gamma-ray sky is dominated by blazars, a class of active galactic nuclei (AGN) that exhibit powerful, variable broadband emission, likely due to observing a relativistic jet aimed close to the line of sight. Despite intensive study and modeling, the mechanisms that generate the prodigious emission in these objects are not well constrained. The *Fermi* Gamma-ray Space Telescope provides unprecedented all-sky gamma-ray monitoring, and detected 104 bright blazars with radio counterparts in its first three months of operation [1].

Correlating gamma-ray emission with activity at radio wavelengths can provide a powerful probe of blazar physics. Since 2007, we have carried out 15 GHz observations of the 1158 CGRaBS sources north of $-20°$ declination with the Owens Valley Radio Observatory (OVRO) 40 M Telescope, anticipating many of these sources to be detected by *Fermi* [2]. Each source is observed approximately twice per week with a thermal noise floor of about 5 mJy.

The OVRO 40 m program is a key component of the *Fermi*-GST Multi-wavelength Monitoring Alliance (F-GAMMA) project [3, 4]. Also within the F-GAMMA project,

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spectra of a smaller sample of about 60 bright sources, selected *ad hoc* based on historically interesting behavior, are monitored monthly at twelve frequencies between 2.7 and 270 GHz using the Effelsberg 100 m and Pico Veleta 30 m telescopes. This coordinated strategy provides both broad spectral monitoring of a moderate number of sources, as well as high-cadence monitoring of a very large, statistically well-defined sample well-suited for population studies.

RADIO-GAMMA CONNECTION

A connection between radio and gamma-ray emission, manifested in a correlation between flux densities in the two bands, would be important evidence for common emission origins. In the EGRET era, some evidence for such a connection was found, but could not be convincingly demonstrated to reflect an intrinsic correlation in source luminosities [5]. A number of red shift and sample selection effects can work to induce an apparent correlation. Recently, Kovalev et al. [6] found an apparent correlation of *Fermi* gamma-ray photon fluxes with quasi-simultaneous 15 GHz radio core flux densities.

We have developed a Monte Carlo method for evaluating the significance of apparent correlations that accounts for both red shift and selection effects and is compatible with sample selection methods that cannot be quantified or reproduced. Our method uses randomly-paired luminosities and red shifts from the true data set to construct a comparison sample with no intrinsic correlations. By constructing many such samples, the probability density for chance correlations can be estimated and used to evaluate the significance of the observed correlation.

Applying this method to the 52 sources in our sample from the *Fermi*-LAT 3-month bright AGN list gamma-ray flux densities from Abdo et al. [1] and the OVRO 15 GHz and F-GAMMA radio data, we find statistically significant flux density correlations. Using the OVRO 15 GHz data, we find a statistically significant Pearson product-moment correlation coefficient $r = 0.56$, with a probability of about $P = 5 \times 10^{-4}$ to find a larger correlation by chance. Using multifrequency F-GAMMA data shows a strong correlation ($r = 0.89$, $P = 4 \times 10^{-5}$) at 140 GHz and a decrease in correlation as the radio frequency decreases.

We conclude that we have found clear evidence for a statistically significant correlation between radio and gamma-ray flux densities that is not the result of red shift or selection effects. This work is supported in part by NASA NNX08AW31G and the NSF AST-0808050.

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