The Relation Between the Radio and Gamma-Ray Emission in Blazars from 15 GHz Monitoring with The OVRO 40 m Telescope and Fermi-GST observations

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Fermi meets Jansky – AGN in radio and gamma-rays
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Overview

• **Problem:**
  – Where does the gamma-ray emission originate in blazars?
    • Various alternatives, e.g. Blandford and Levinson 1995, Marscher et al 2008

• **Our strategy:**
  – Study radio and gamma-ray light curves for a large number of sources
    • Monitoring 1500 sources
    • 454 detected by *Fermi*-GST on 1LAC “clean” sample
Introduction

Double peaked SEDs


Artist impression
http://imagine.gsfc.nasa.gov/
Introduction

Variability and linear polarization

3C 279 multi-wavelength campaign, Abdo et al. 2010, Nature 463, 919
Introduction:

**Gamma-ray emission zone**

- Different classes of models
  - Composition of the jet
  - Origin the inverse Compton soft photons
  - Distance from the central engine

_Blandford and Levinson 1995_  
_ApJ 441, 79_
Introduction: 
**Gamma-ray emission zone**

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*Marscher 2005, Mem. S.A. It 76, 13*
Observing program: Radio monitoring

- OVRO 40-meter blazar monitoring
  - since July 2007
  - 1158 candidate gamma-ray blazars all CGRaBS objects with $\delta > -20^\circ$
    - CGRaBS, uniform and complete
  - Fermi detected sources are added, current sample $\sim 1500$ sources

Distribution of CGRaBS sources in Galactic coordinates
Red circles represent monitored blazars
Observing program: Radio monitoring

• System parameters
  – Dual-beam Dicke-switch system
    • FWHM 2.5', Beam separation 13'
    • 15 GHz, 3 GHz bandwidth
    • Tsys ≈ 50 K, Trx ≈ 30 K
    • Lose a factor of 2 in sensitivity compared to ideal receiver

• Observations
  – ~ two fluxes per week
  – ~ 5 mJy thermal noise, ~2% flux proportional uncertainty
  – Periodic relative calibration with noise diode
  – Absolute calibration with 3C286

The 40 m Telescope in action

Three full days of observations with the OVRO 40m Telescope video courtesy of Joey Richards
First results: Almost 3 years of observations

- Examples of gamma-ray/radio light curves for 3 month Fermi detected sources, 52 objects in total
First results:
Almost 3 years of observations

- Examples of gamma-ray/radio light curves for 3 month Fermi detected sources, 52 objects in total
First results:
Public data release

• Visit our website for more information

http://www.astro.caltech.edu/ovroblazars
First results:
Radio/gamma-ray correlation

- The apparent correlation is confirmed using simulations

\[
\begin{align*}
\text{Flux density correlation} \\
\text{Correlation significance}
\end{align*}
\]

\[
\begin{align*}
\text{Radio flux density} \\
15 \text{GHz Flux (Jansky)} & \quad 100 \text{MeV flux (GeV/cm}^2 \cdot \text{s} \cdot \text{GeV)} \\
\text{Gamma-ray flux density} & \\
\text{Monte-Carlo evaluated probability density} \\
\text{data} \\
r = 0.61 \\
P(\text{chance}) = 2 \times 10^{-4}
\end{align*}
\]
First results: Radio/gamma-ray time lags

- Examples cross-correlations. 3 month Fermi detections, using 11-months of Fermi data and 2 years of radio monitoring
- Significance evaluated using simulated data with a power-law PSD $\sim 1/f^\beta$:
  \[
  \beta_{\text{radio}} = 2.5, \quad \beta_{\text{gamma}} = 2.0
  \]
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First results:  
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• Examples cross-correlations. 3 month Fermi detections, using 11-months of Fermi data and 2 years of radio monitoring

• Significance evaluated using simulated data with a power-law PSD $\sim 1/f^\beta$ \[
\beta_{\text{radio}} = 2.5, \\
\beta_{\text{gamma}} = 2.0
\]
New receiver:

**Polarization and better sensitivity**

- New receiver will measure polarization
  - Polarization variability related to magnetic field structure on emission region
- Increases sensitivity
  - Both polarizations
  - Wider bandwidth
- Under construction
  - Radio frequency components design and acquisition
  - Digital backend
- Commissioning expected by end of the year
Summary

• First results:
  – Radio/gamma-ray flux density correlation is significant
  – Radio/gamma-ray time lags require longer duration light curves

• *Fermi*-GST provides a large sample of gamma-ray blazars with improved sensitivity and cadence. These are being observed by the OVRO 40-m Telescope plus all CGRaBS

• The correlated variability at these two bands will be used to constrain the location of the gamma-ray emission zone

• A new receiver which measures polarization is under development and commissioning is planned for the end of the year