The Broadband SEDs of the MOJAVE sample

Chang, Chin-Shin$^{1,2,3}$
Max-Planck-Institut für Radioastronomie

$^1$Member of International Max Planck Research School of Astronomy and Astrophysics
$^2$Member of ESTRELA Network
$^3$Affiliated graduate student of the *Fermi/LAT* collaboration
The Emission of AGN Jets

Open questions:

- Where is the emission of AGN jets generated
- What are the mechanisms to produce high-energy emission of blazars: leptonic (SSC, EIC), hadronic (photon-photon), or both?

(Chang et al. in prep.)
"The Spectral Energy Distribution of Fermi Bright Blazars" (Abdo et al. 2010, 716,30), a $\gamma$-ray selected sample was studied.

We want to attack the problem using a radio-selected sample.
The Broadband SED Catalog

• Construct a broadband SED catalog of 135 MOJAVE sources (statistically complete, see Lister, this conf.)

• The MOJAVE sample has
  • 101 flat-spectrum radio quasars
  • 22 BL Lac objects
  • 8 radio galaxies, 4 unidentified objects

  Continuously monitored in the radio band

• Use simultaneous datasets from radio to $\gamma$-ray bands
Broadband SED data


- **Swift** observations

- **[X-ray/Optical] XRT/UVOT**: Dedicated program to observe MOJAVE sources, observations after August 2008


- **[Radio] FGAMMA monitoring** (Fuhrmann et al. & Angelakis et al. 2010, this conf.)
Broadband SED data


- **Swift** observations

- **[X-ray/Optical]** XRT/UVOT: Dedicated program to observe MOJAVE sources, observations after August 2008

- **[Hard X-ray]** BAT: 22-month catalog (J. Tueller et al. 2010, accepted by the ApJS)


- **[Radio]** FGAMMA monitoring (Fuhrmann et al. & Angelakis et al. 2010, this conf.)
**Swift simultaneous obs.**

<table>
<thead>
<tr>
<th>Source</th>
<th>Swift (0119+115)</th>
<th>Swift (0730+504)</th>
<th>Swift (1150+812)</th>
<th>Swift (1637+574)</th>
<th>Swift (1936-155)</th>
<th>Swift (2121+053)</th>
<th>Swift (1045-188)</th>
<th>Swift (2134+004)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fermi 1FGL</td>
<td>0224+671</td>
<td>0738+313</td>
<td>1213-172</td>
<td>1655+077</td>
<td>1957+405</td>
<td>2128-123</td>
<td>1417+385</td>
<td>0945+408</td>
</tr>
<tr>
<td>Non Fermi 1FGL</td>
<td>0238-084</td>
<td>0804+499</td>
<td>1413+135</td>
<td>1741-038</td>
<td>2005+403</td>
<td>2136+141</td>
<td>1638+398</td>
<td>0742+103</td>
</tr>
</tbody>
</table>

84% of MOJAVE source has broadband coverage of **radio, optical, X-ray and γ-ray**

Currently using **Swift** data before Aug. 2008; will be completed by the dedicated **Swift** program.
Data Analysis

• Typical exposure: 5-10 ks of Swift/XRT obs., providing good X-ray spectra

• *Swift*/XRT spectra fitted by an absorbed power-law model with a lower-limit of NH value measured by the LAB survey (Kalberla et al. 2005, A&A 440, 775)
Data analysis

- A polynomial model is applied to all broadband SEDs (as a first approach)
Data analysis

- A polynomial model is applied to all broadband SEDs (as a first approach)

- We estimated the peak positions of the synchrotron and high-energy humps
Correlation study

Radio (VLBI):
Flux density
Spectral index $\beta_{\text{app}}$
Doppler factor
Lorentz factor

$\gamma$-ray:
Flux
Luminosity
Photon index

Pushkarev et al. 2010, submitted to A&A
Boeck et al., this conf.
Correlation study

**SED:**
- $\nu_{\text{sync}, \text{peak}}$
- $\nu F_{\nu \text{ sync}, \text{peak}}$
- $\nu_{\text{IC}, \text{peak}}$
- $\nu F_{\nu \text{ IC}, \text{peak}}$

**Radio (VLBI):**
- Flux density
- Spectral index $\beta_{\text{app}}$
- Doppler factor
- Lorentz factor

**X-ray:**
- Flux
- Luminosity
- Photon index

**$\gamma$-ray:**
- Flux
- Luminosity
- Photon index
Preliminary
Results

- Broadband SED of 6 representative sources
  Quasars: NRAO 530, B2209+236, 4C +71.07
  BL Lacs: 4C +47.08, B0754+100
  Radio galaxy: 3C 111

- Preliminary analysis
NRAO 530
High-polarized radio quasar
*Swift* obs. in June 2009 (5 ks)

B2209+236
Flat-spectrum radio quasar
*Swift* obs. in April 2009 (9 ks)
4C +71.07
Quasar
*Swift* obs. in February 2010 (9 ks)

3C 111
Broad-line FR II radio galaxy
*Swift* obs. in January 2010 (9 ks)
4C +47.08
BL Lac object
*Swift* obs. in September 2008 (7 ks)

B0754+100
Low-frequency peaked
BL Lac objects (LBL)
*Swift* obs. in February 2010 (9 ks)
Preliminary

Number of objects

X-ray photon index

log X-ray Luminosity [erg/s]
Summary

- We have constructed a (quasi-)simultaneous broadband SED catalog for a radio-selected AGN sample of 135 sources.
- We estimated the peak positions of the synchrotron and inverse Compton humps.
- We are investigating possible correlations of:
  - e.g. $\gamma$-ray luminosity - Peak flux of IC hump
Next Steps

• Statistical tests will be performed to confirm our findings

• Variability study of broadband SED of individual sources

• Physical modeling of the broadband SEDs