KANATA Optical and NIR monitoring of Fermi AGNs

Yasushi Fukazawa, Makoto Uemura, Mahito Sasada, Koji Kawabata, Ryosuke Itoh, Hajimu Yasuda, Syoko Yamazaki, on behalf of the Fermi-LAT and KANATA collaborations

HIROSHIMA UNIVERSITY

Abstract: The Kanata telescope at Higashi-Hiroshima Observatory has been monitoring Fermi AGNs in the optical/NIR band. AGNs are observed with TRISPEC (3-color-photometry-polarimetry) and HowPOL (1-color-photometry-polarimetry and optical spectroscopy). In the first year, we observed about 40 blazars including Fermi bright or flaring AGNs. A summary of optical studies using this large sample of data will be published soon. In the 2nd year, we observed several important AGNs, including 3C279 and 3C66A. Continuous optical monitoring data with polarization data are very valuable in constraining the emission parameters and magnetic field. In fact, Kanata found a rotation of the polarization angle from 3C279, associated with GeV flares. Rotations of polarization angles were sometimes observed for 3C454.3. 3C66A showed two types of optical and GeV gamma-ray correlations; sometimes they correlated well, but sometimes only the optical flux increases over a long timescale. Optical spectroscopy monitoring of a radio galaxy NGC1275 showed that the intensity of broad H-alpha lines is almost contant within 20% while GeV gamma-ray flux are variable by a factor of 50% or larger. We report here some results for Fermi AGNs, including the above issues.

Main Instruments for the KANATA Telescope

HOWPol (1st Nasmyth)

2009--
Optical and NIR (B, V, R, I, z)
Photometry
One-shot Polarimetry
Spectroscopy(R=400)

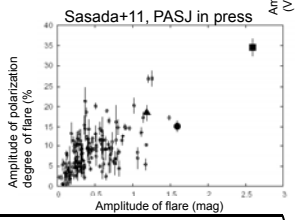
Image : R < 19.2 mag
Pol : R < 16.0 mag

TRISPEC (Cassegrain)

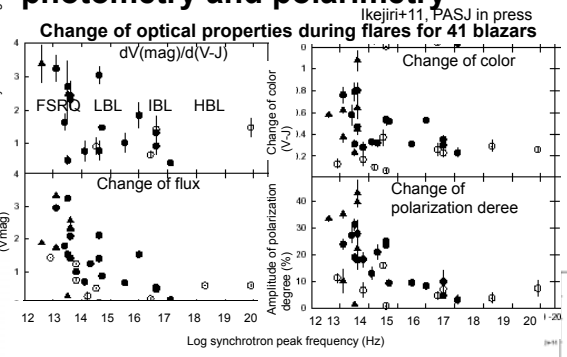
2006--
Optical and NIR
Simultaneous multi-color Photometry (V, J,H, Ks) and Polarimetry (V,J,Ks)

Image : V < 18.5 mag
J < 16.8 mag
Ks < 15.1 mag
Pol : V < 16.0 mag

KANATA is one of the fastest moving telescope with this size (1.5m) in the world, and can quickly respond to blazar flares reported by Fermi and other telscopes..



KANATA monitored 41 blazars with photometry and polarimetry

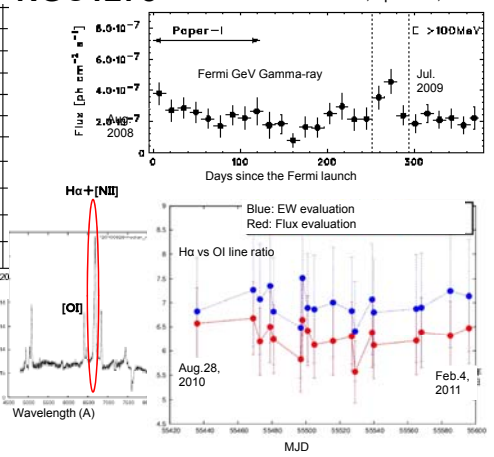


Ikejiri et al.(PASJ in press) summarized the KANATA monitoring of 41 blazars. All the light curves of flux, color, polarization degree are presented. Using this unprecedented large amount of data, we studied the systematic behaviors of optical properties during flares.FSRQs tend to show a large change of flux, color, and polarization degrees, while HBL tends to show a little change.

As shown in the left panel, large optical flares often showed a high polarization degree, indicating that the flare occurs in the region with aligned magnetic field.

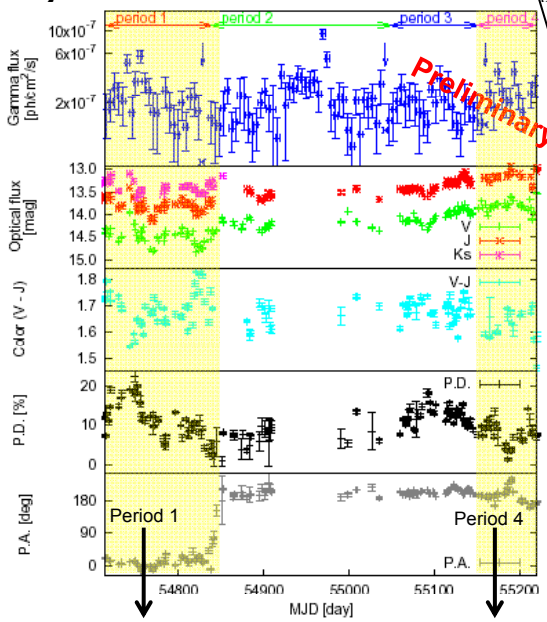
Spectroscopic and polarimetric monitoring of a radio galaxy NGC1275

Kataoka+11, ApJ 715, 554



We are monitoring a GeV gamma-ray radio galaxy NGC1275 with KANATA by spectroscopy and polarimetry. NGC1275 showed a significant time variability in the GeV band by a factor of 1.5 within 1 year. However, a broad Ha line is almost constant within 20% over half a year, indicating that the disk emission is not so variable as the jet emission. Results of polarization will be available after precise calibration of HOWPol.

Two types of optical and gamma-ray correlations for 3C66A

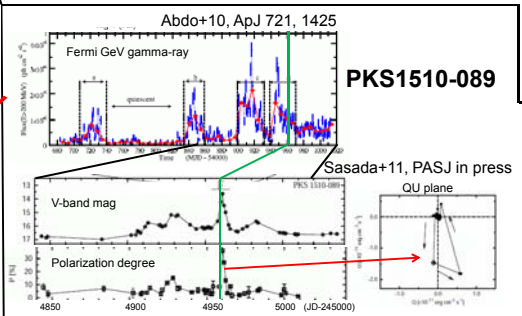


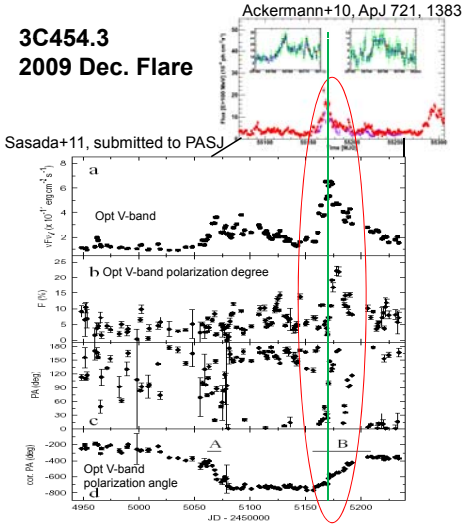
3C66A showed two types of correlation between the GeV gamma-ray and optical. In the period 1, they correlated well, together with the color and polarization degree. In the period 4, only the optical flux increased and no clear correlation was seen among various quantities. The period 1 was reported in Abdo et al. (2011, ApJ 726, 23), and its SED was explained by the SSC+EC model. On the other hand, in the period 4, the gamma-ray increase was not clear and only the synchrotron optical emission increased, indicating that the seed photon of the EC was poor, as calculated in the following. using these formula (Sikora+07).

$$\frac{L_{\rm ERC}}{L_{\rm sync}} \sim \Gamma^2 \frac{u_{\rm ext}}{u_{\rm B}} \qquad u_{\rm ext} \sim \frac{B^2}{8\pi\Gamma^2}\frac{L_{\rm ERC}}{L_{\rm sync}} \qquad u_{\rm sync} = \frac{L_{\rm sync}}{4\pi R^2 c \delta^4}$$

Period	Optical flux [erg/s/cm²]	Gamma-ray flux @20GeV [erg/s/cm²]
Period 1	3.2×10^{-11}	3.5×10^{-11}
Period 4	6.0×10^{-11}	3.8×10^{-11}

Parameter	z = 0.1	z = 0.2	z = 0.3	z = 0.444
Comoving magnetic field, B[G]	0.35	0.22	0.21	0.23
jet Lorentz factor Γ	30	30	40	50
size of blob R [10^{16}cm]	0.5	1.2	1.5	1.5
$u_{\rm sync}$ (period 1) [10^{-5} erg/cm^3]	10.56	8.36	4.27	4.40
$u_{\rm sync}$ (period 4) [10^{-5} erg/cm^3]	19.60	15.51	7.92	8.17
$u_{\rm ext}$ (period 1) [10^{-7} erg/cm^3]	58.61	22.98	11.78	9.04
$u_{\rm ext}$ (period 4) [10^{-7} erg/cm^3]	29.21	11.54	5.92	4.54





Rotation of polarization angle

Rotation of the optical polarization associated with the GeV gamma-ray flare was found for the first time for 3C279. The duration of rotation was around 15 days, indicating that the gamma-ray emission region is far from the black hole.

Rotation of the optical polarization angle was also observed during the 2009 Dec. giant flare of 3C454.3. V-band flux well correlated with the GeV gamma-ray, and the polarization degree increased with a delay of 5 days or so. Polarization angle rotated by 350 deg within 30 days ("B" in the figure). Note that the polarization angle rotated inversely at the onset of the active phase including the giant flare ("A" in the figure). We also monitored the 2010 flare, and found that the behavior of polarization was different from that in 2009.

However, rotation did not necessarily occurred in accordance with GeV gamma-ray flares. PKS1510-089 showed the rotation for one of several gamma-ray flares, which was prominent in the optical light curve.

3C279 Abdo+10, Nature 463, 919