

TimeTubes

Visualization of polarization in blazars

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Itoh, R., Xu, L., Nakayama, M., Wu, H. Y., Watanabe, K., Takahashi, S., Fujishiro, I.

2 Jun. 2016 @Blazars through Sharp Multi-Wavelength Eyes

“Kanata” - the 1.5-m telescope in Hiroshima

Telescope for time-domain astronomy

Polarization

Opt. & NIR simultaneous observations

Blazars: one of our main targets

Ikejiri, et al. 2011, PASJ, 63, 639

Uemura, et al. 2010, PASJ, 62, 69

, and other papers by Sasada-san and Itoh-san

2007—2014: >3,000 data points of 42 blazars



Polarization variations in blazars

Diagnostics for jet field structure

One component?
Simple behavior?

Yes



Easy to see variations in
the time-series of P & θ

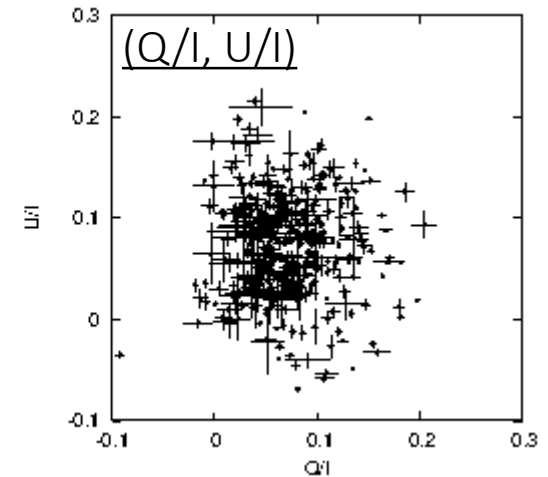
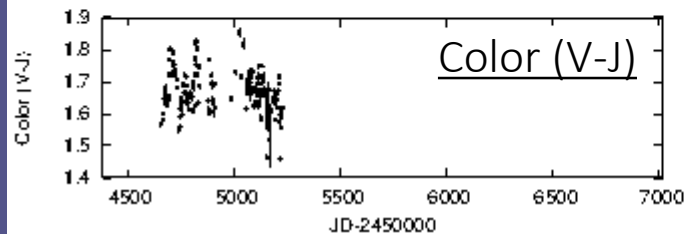
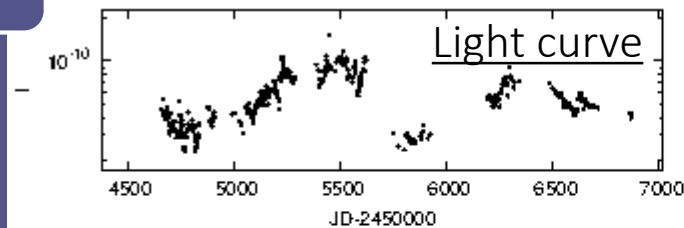
No



Hard to see variations in
the QU plane

Light curve, Color, and Stokes Q/I , U/I of 3C 66A obtained with Kanata

More data,
less insight



Visualization of polarization variations

Demo.

TimeTubes

Xu, et al. 2016, the proceedings of the NICOGRAPH international 2016
<http://fj.ics.keio.ac.jp/index.php/projects/spm/>

Collaboration with researchers of visualization

Prof. Issei Fujishiro

Ms. Longyin Xu (graduate student)

in Keio University

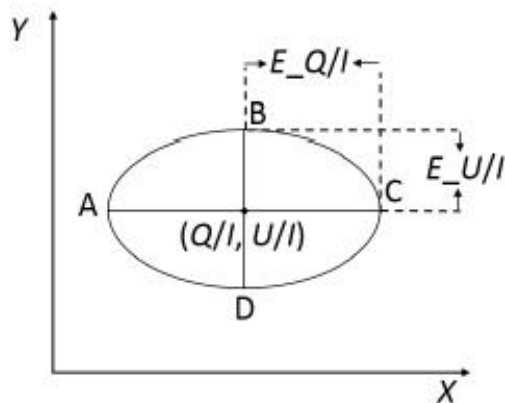
Tube's

Center = Q/I and U/I

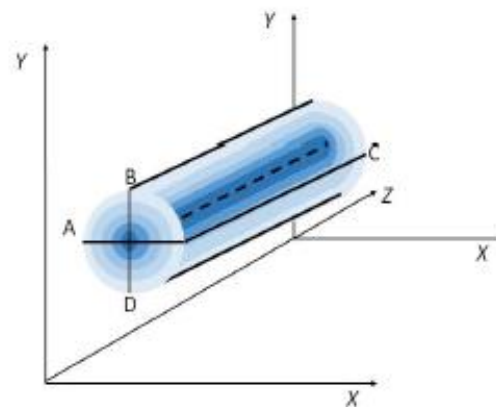
Diameter = measurement errors of Q/I and U/I

Brightness = total flux

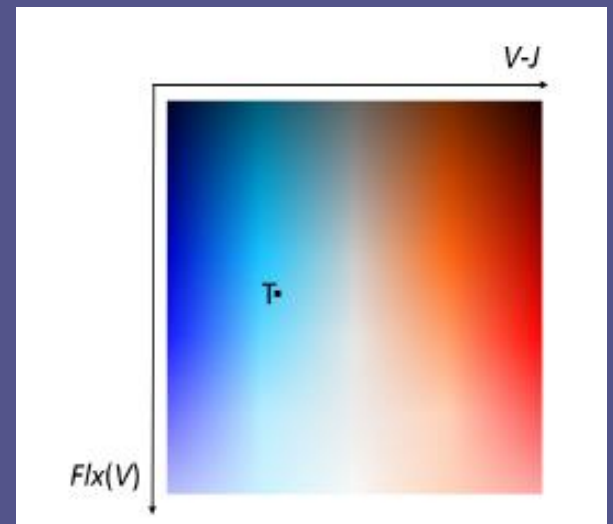
Color = color (V-J)



(a)



(b)

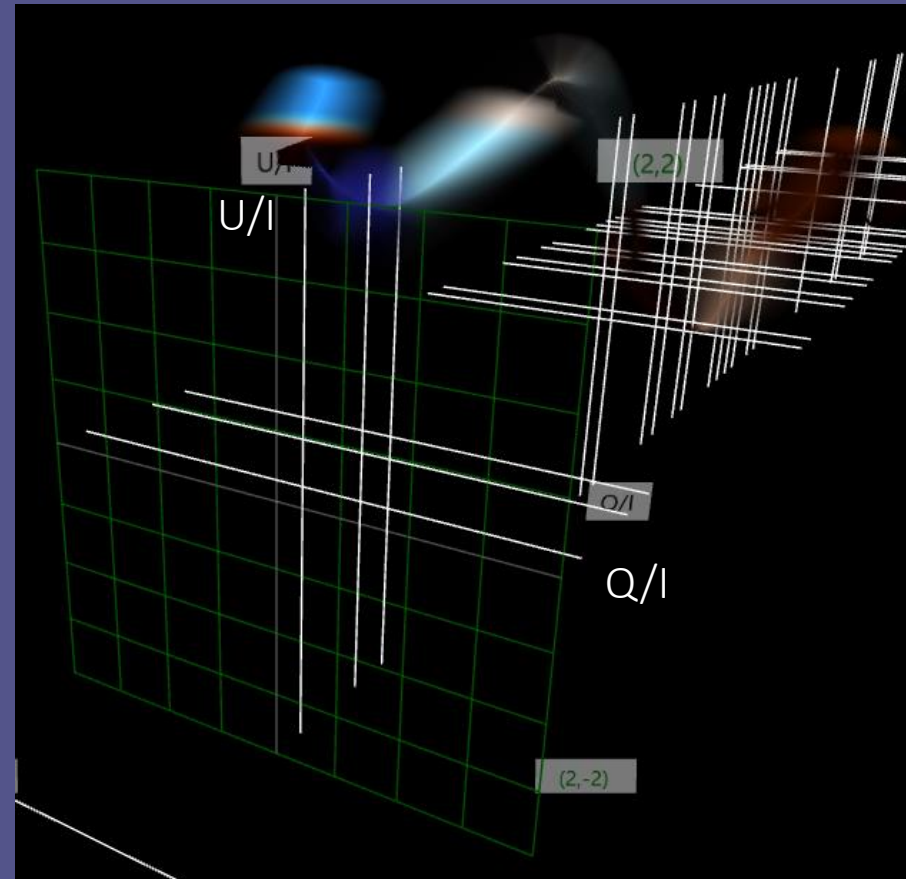
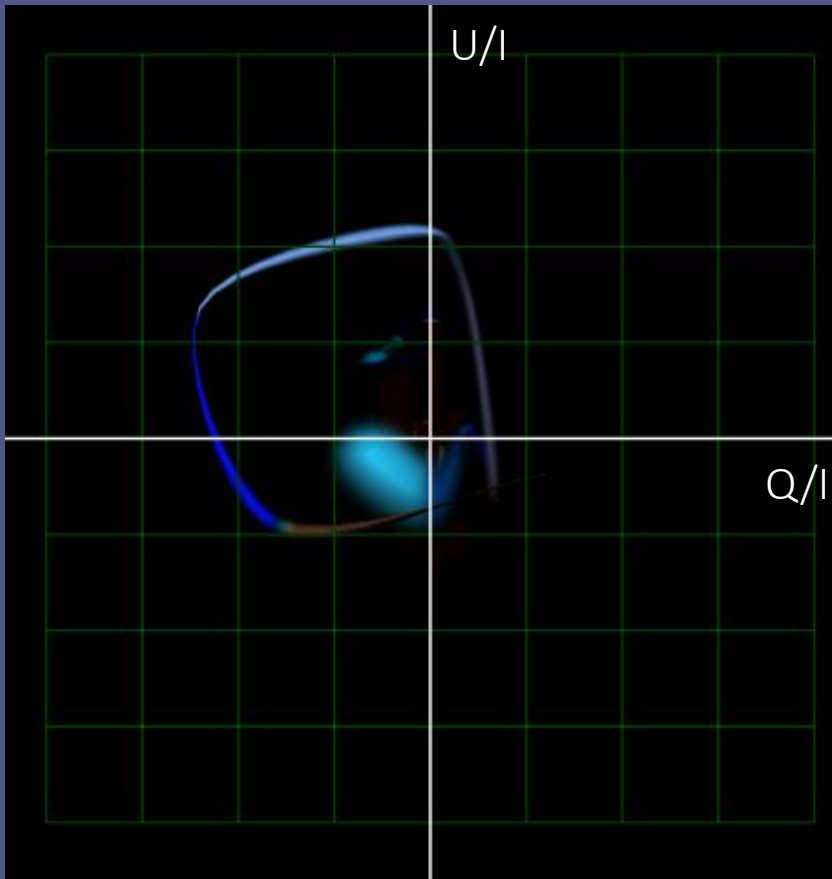


PKS 1749+096

Insights from TimeTubes

- PA rotation
- Flares favoring a small range of PA

⇒ Confirmation in classical views



PKS 1749+096

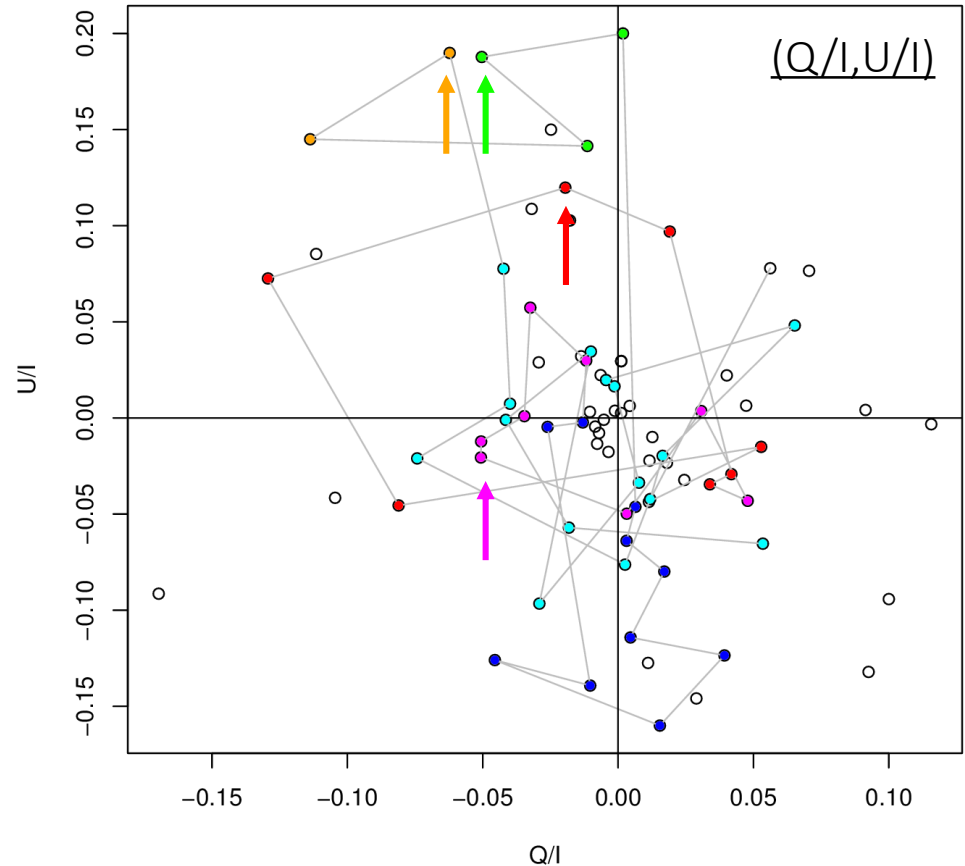
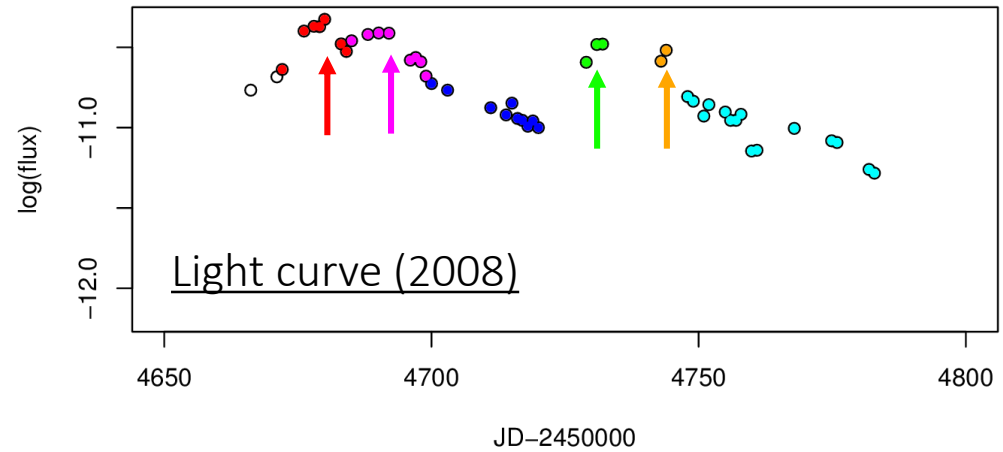
Flares tend to have PA=50-60 deg

Fading tails have PA=-40 - -50

A PA rotation was associated with the flare MJD 54672—54685

P-value = 0.07 (KS test)

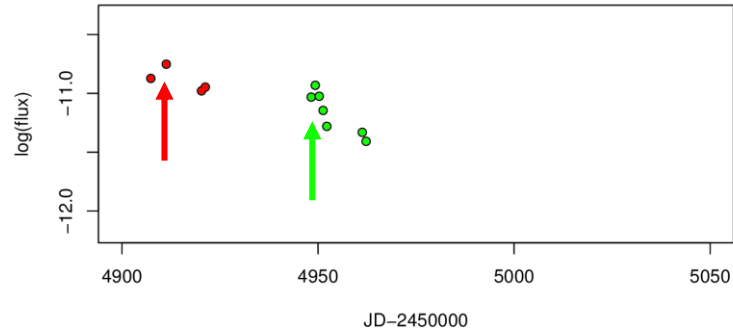
This flare reached its peak also at PA=50-60



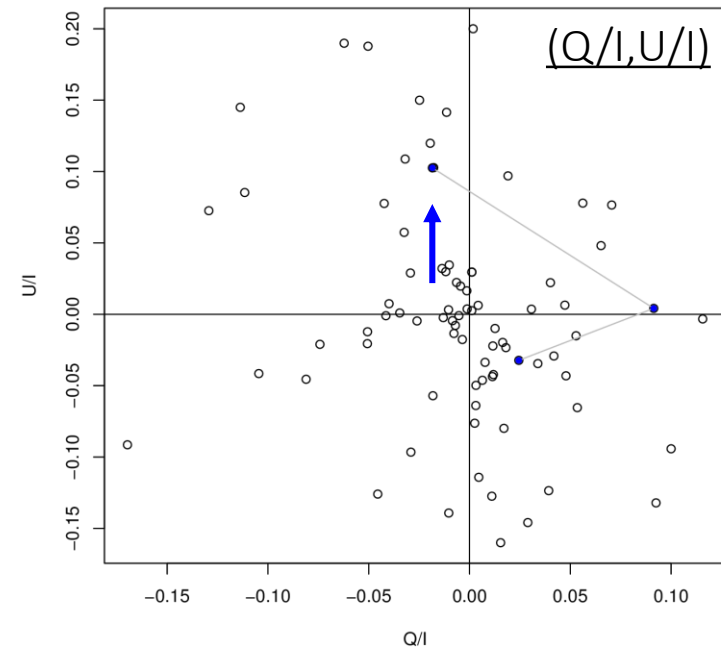
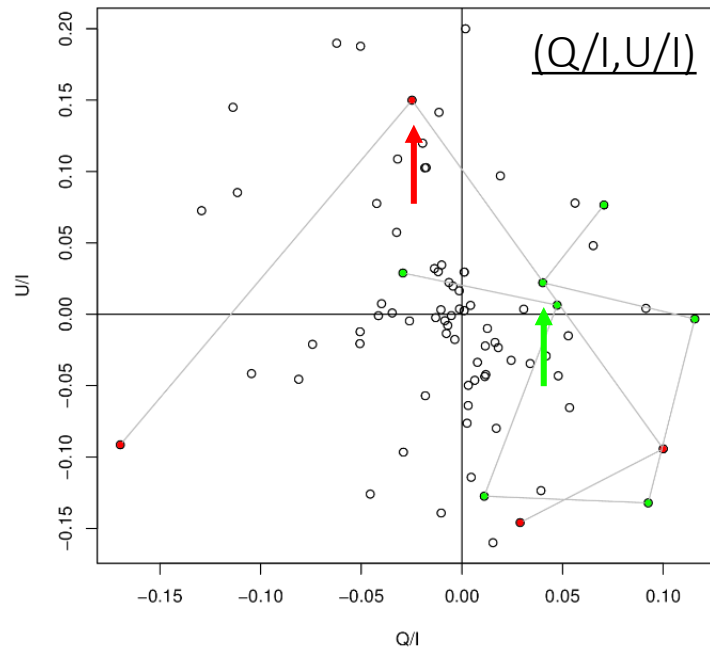
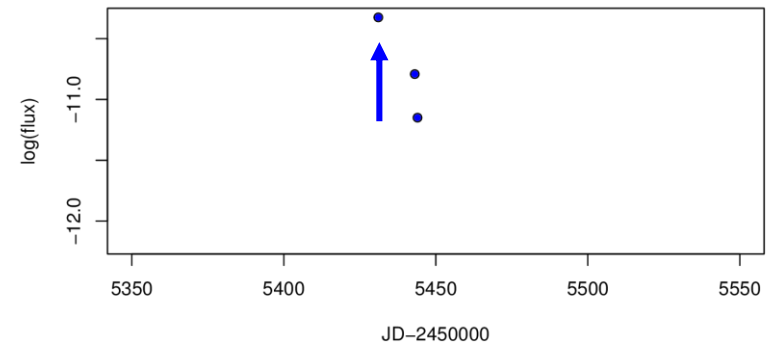
Poor data after 2009, but...

Hints of PA rotation and favored PA

Light curve (2009)



Light curve (2010)



PKS 1749+096: VLBI images

(Lu, et al. 2012)

Upstream jet : -20 – +40 deg
 → Downstream jet: +30 – +40 deg
 ~ flare PA

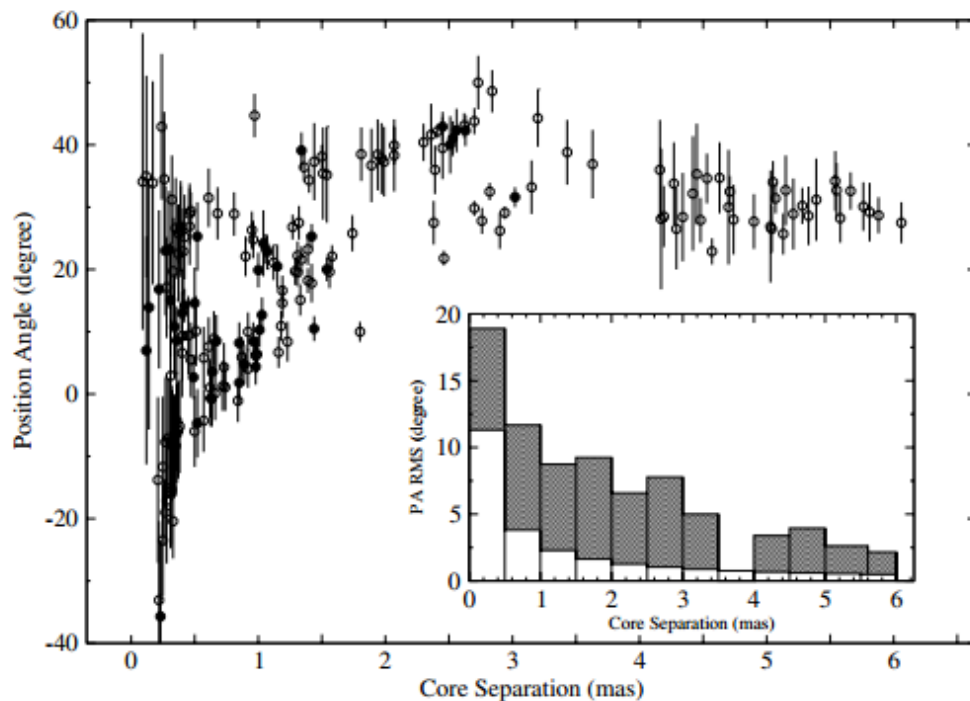
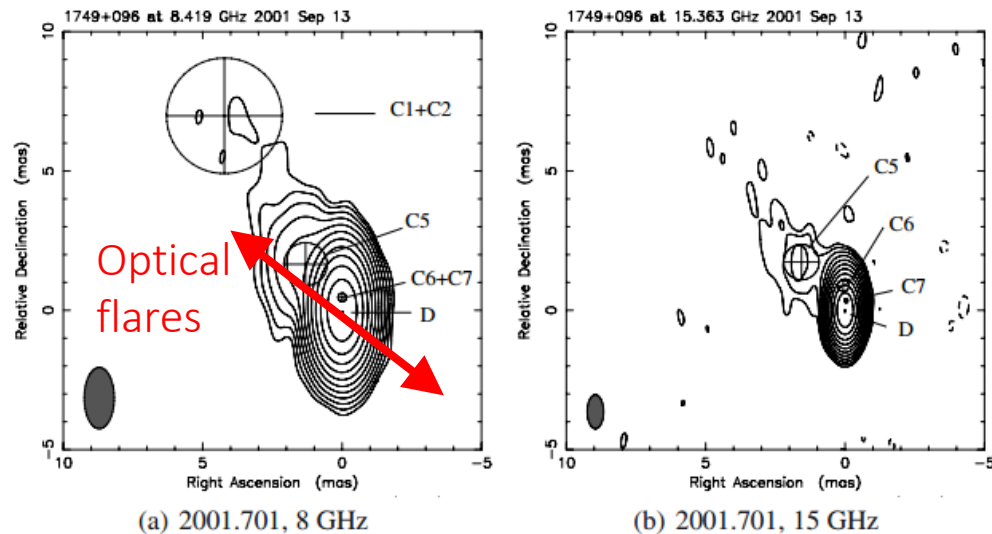


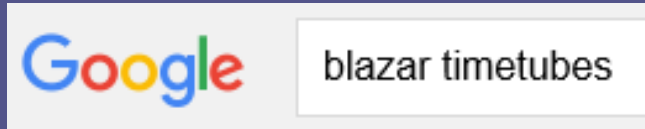
Upstream region

A wide range of

- the position angles of the radio knot
 - the optical polarization angle (PA rotation → helical B?)
- Optical flares = beaming factor?

R.-S. Lu et al.: The parsec-scale jet of PKS 1749+096





Summary

We have developed “TimeTubes” for the visualization of variations in blazar polarization.

We can “see” the time variations in six variables, that is, the total flux, color, Stokes QU, and their errors in one TimeTubes window.

It helps us to find PA favored by flares and PA rotations.

We found that, in PKS 1749+226, the optical flares favor a narrow range of PA, and the PA rotation event also followed this trend.

TimeTubes is under development, but available in the following site:

Project site

<http://fj.ics.keio.ac.jp/index.php/projects/spm/>

Download

http://fj.ics.keio.ac.jp/share-stuff/TimeTubes_0526v2.zip