

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

2008—2014: 42 objects, >3,000 data points



Polarization variations in blazars

Diagnostics for jet field structure

One component?
Simple behavior?



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

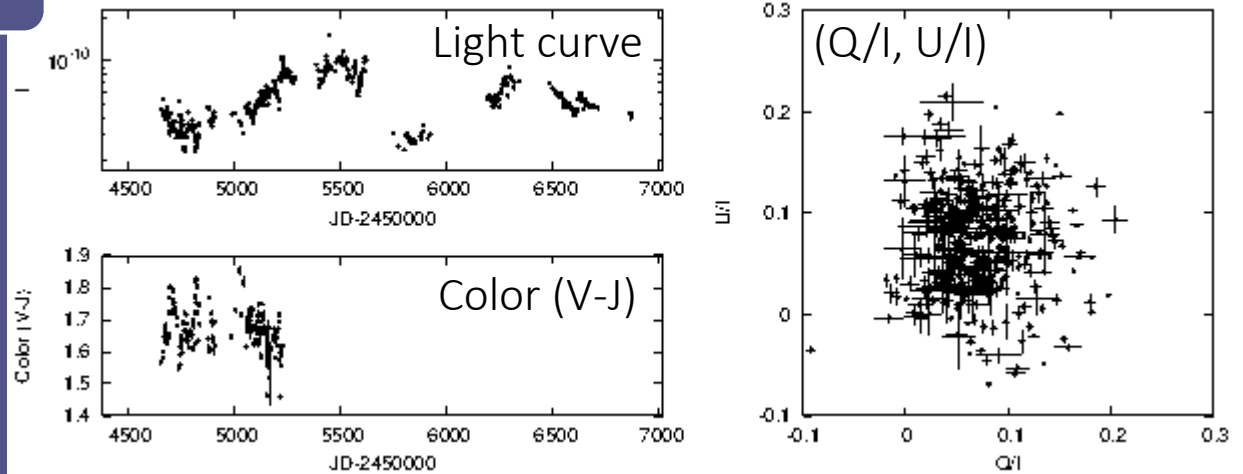


No

Hard to see variations in
the QU plane

More data,
less insight

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



Visualization of polarization variations

Demo.

TimeTubes

Xu, et al. 2016, the proceedings of the NICOGRAPH international 2016
<http://keio...xxx>

Collaboration with researchers of visualization

Prof. Issei Fujishiro

Ms. Longyin Xu (graduate student)

in Keio University

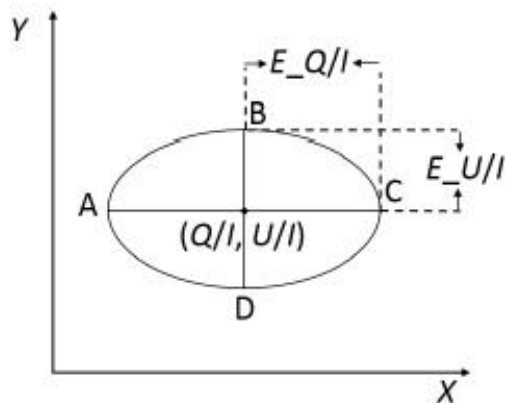
Tube's

Center = Q/I and U/I

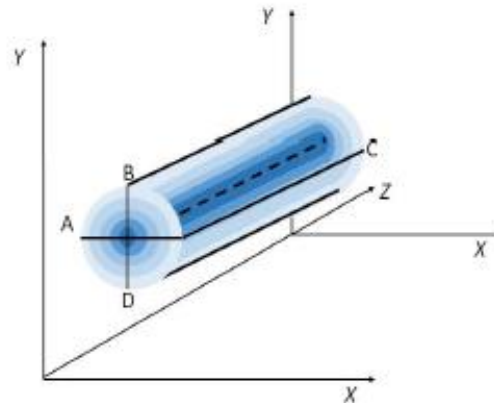
Diameter = measurement errors of Q/I and U/I

Brightness = total flux

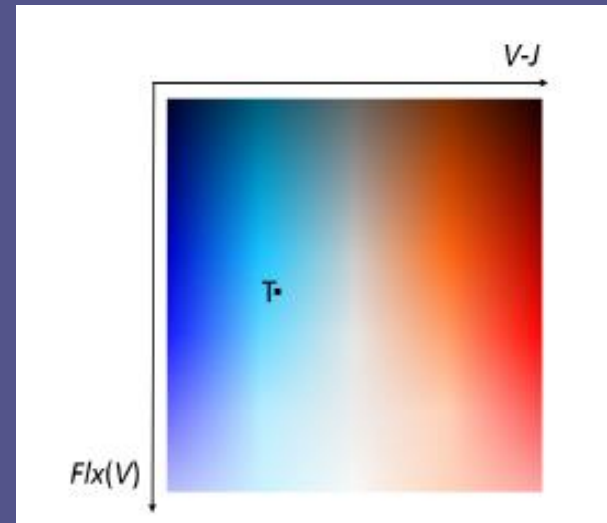
Color = color (V-J)



(a)

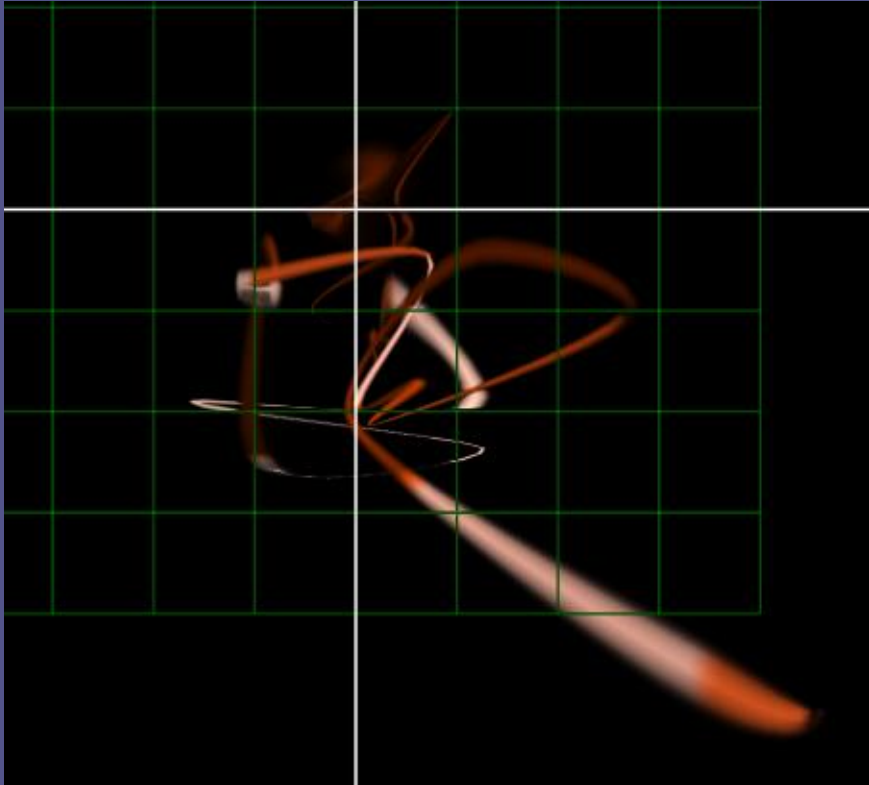


(b)

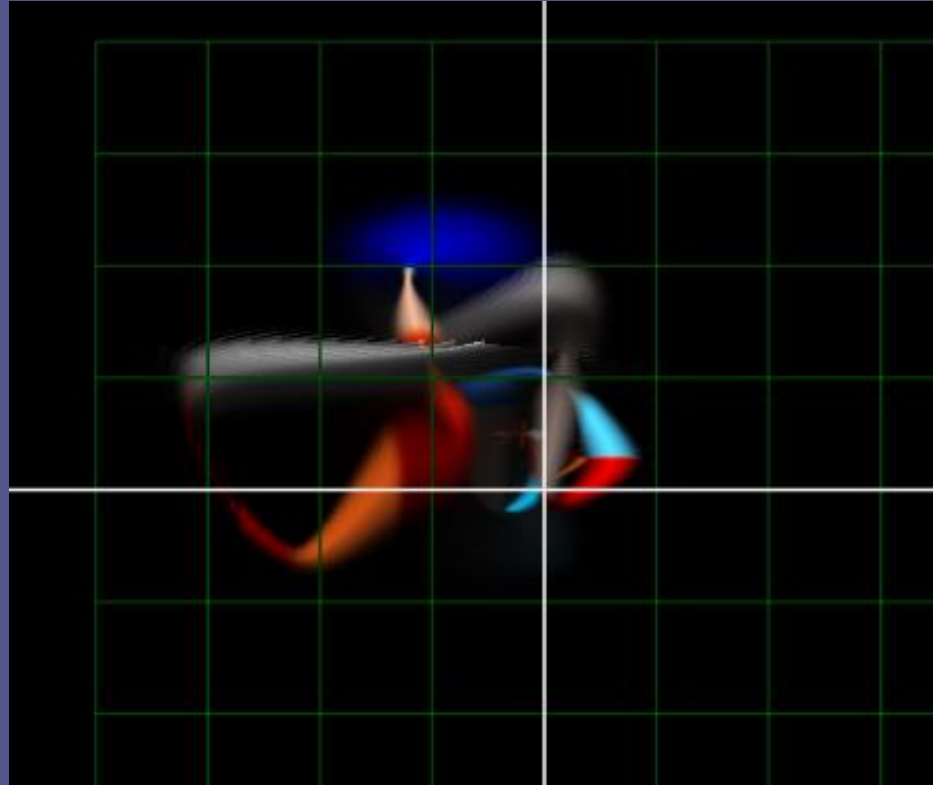


Examples:

3C 454.3: off-center PA rotation of flares



PKS 2155-304: off-center PA rotation



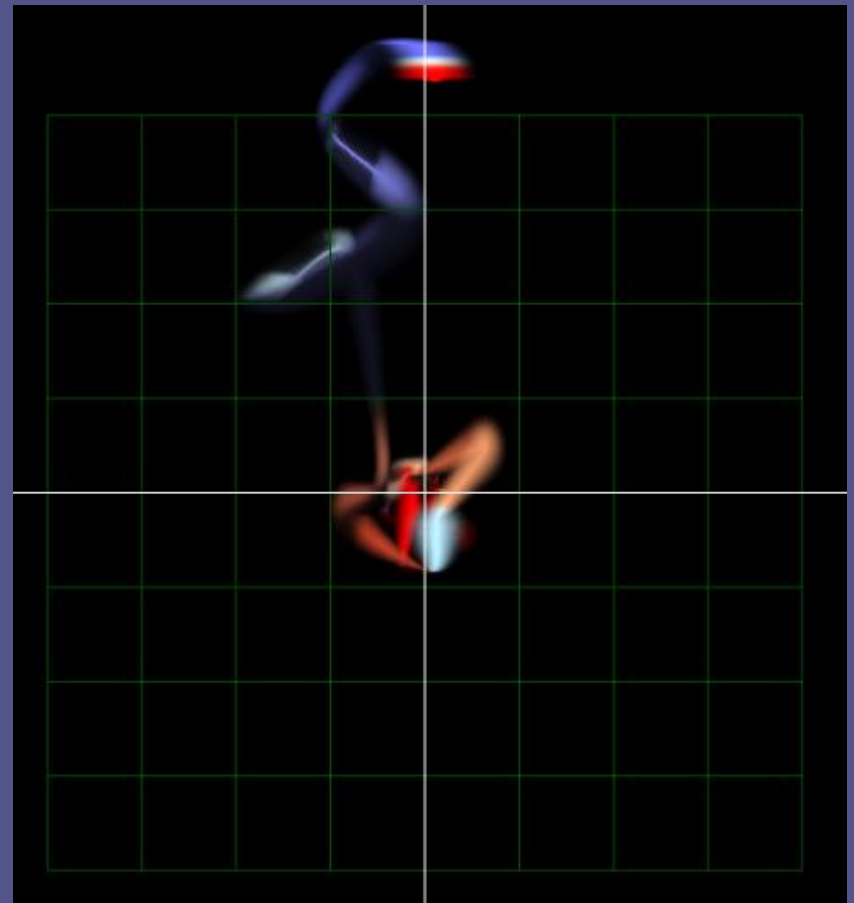
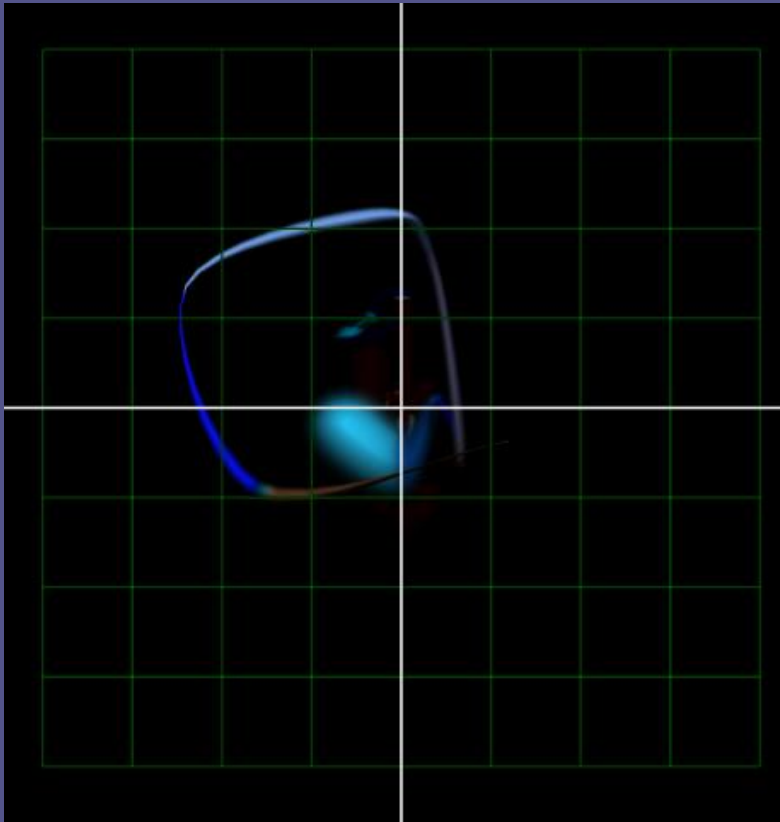
Similar flares were reported in
3C 454.3 in 2007 (Sasada+10)

PKS 1749+096

Insights from TimeTubes

- PA rotation
- Flares favoring a small range of PA

⇒ Confirmation in classical views



PKS 1749+096

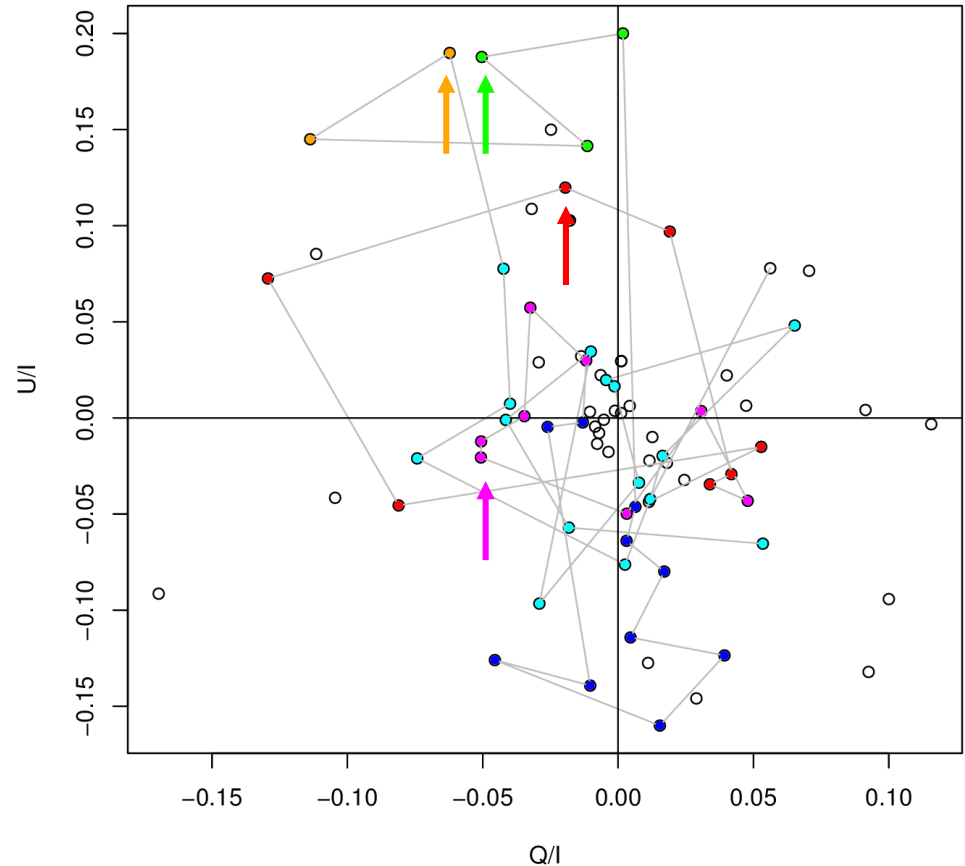
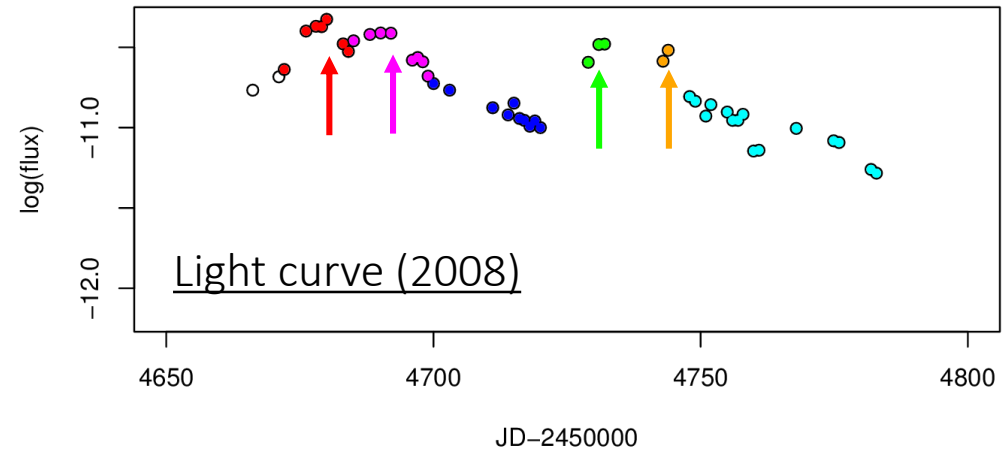
Flares tend to have PA=50-60 deg

Fading tails have PA=-40 - -50

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

P-value = 0.07 (KS test)

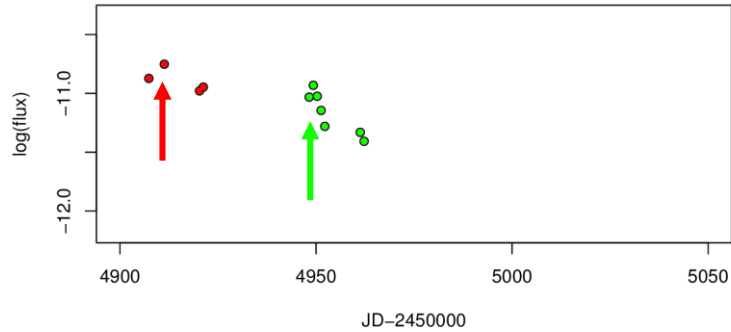
This flare reached its peak also at PA=50-60



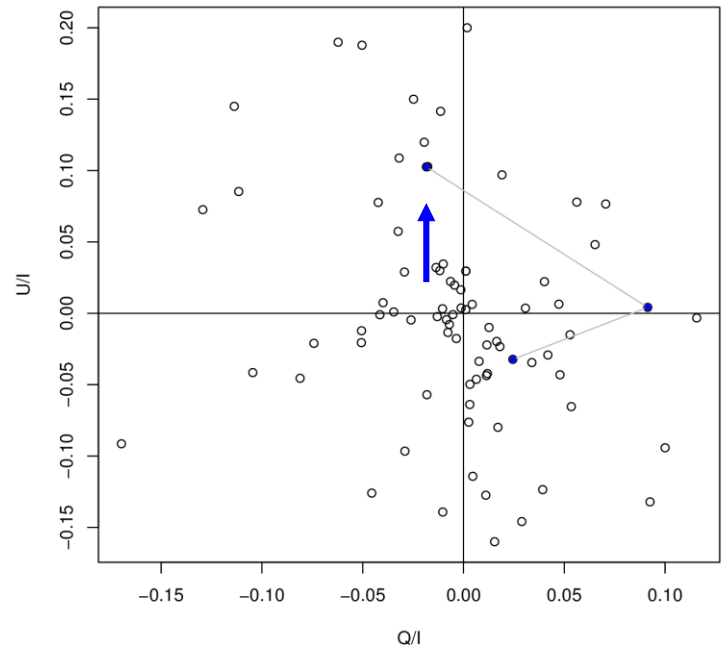
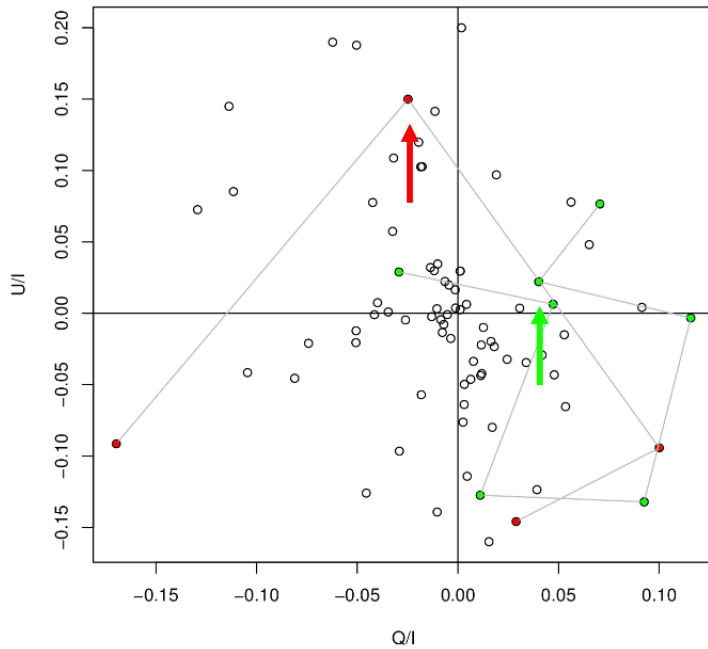
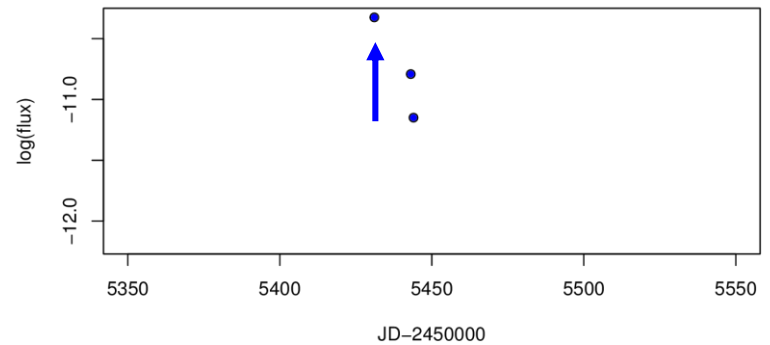
Poor data after 2009, but...

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 – +50 deg
 ~ flare PA



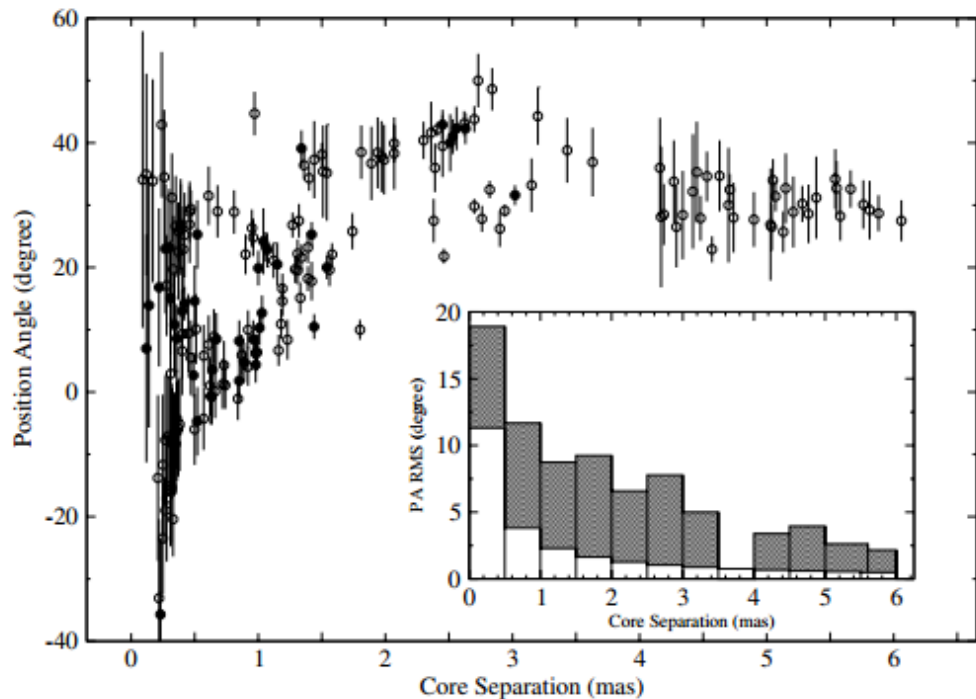
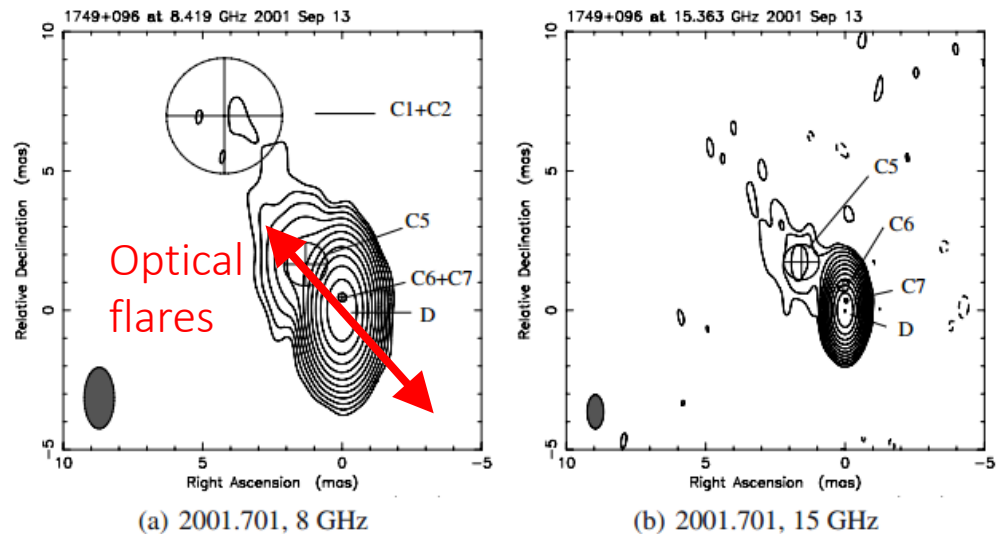
Upstream region

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 visualization of temporal 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 PKS 1749+226 has a favored PA,....

TimeTubes is under development, but available at:

www.keio.ac.jp/..xxx