

Intraday variability of the polarization vector in AGN S5 0716+714

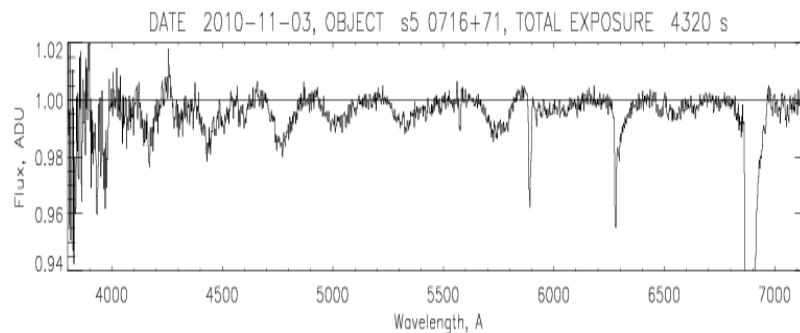
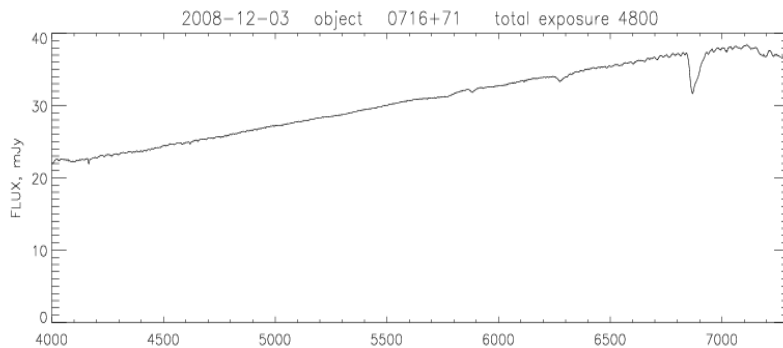
Elena Shablovinskaya, Victor Afanasiev
Special Astrophysical Observatory of RAS



Special S5 0716+714

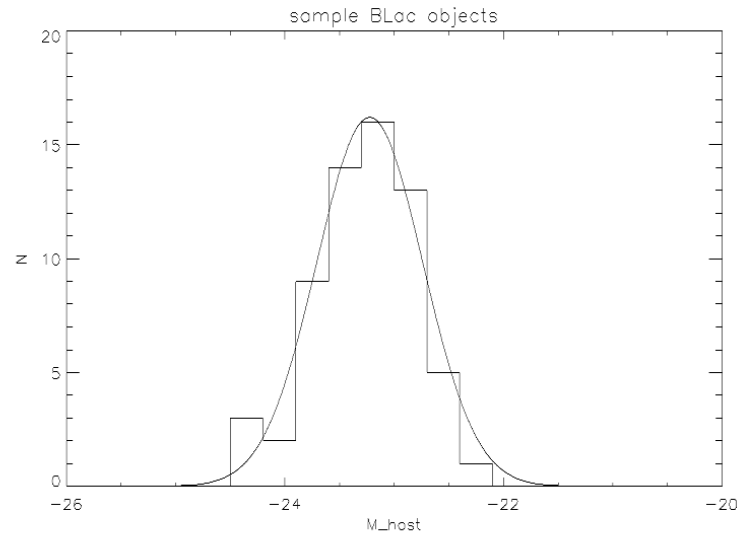
Redshift z - ?

- No spectral details (except interstellar) at 0.3% level (10^{-3} \AA).

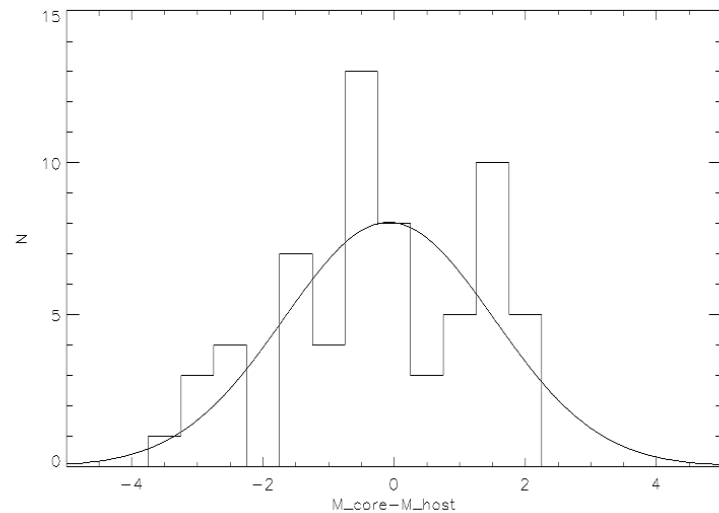


- No evidence of the host galaxy.
- » (Urry et al. 2000) - *HST* survey $\rightarrow m > 20.0^m \rightarrow z > 0.5$
- » (Stickel et al. 1993) $\rightarrow z \approx 0.26$
- » (Bychkova et al. 2006) $\rightarrow z = 0.3$
- » (Nilsson et al. 2008) $\rightarrow z = 0.3$
- » (Stadnik & Romani 2014) $\rightarrow z = 0.127$

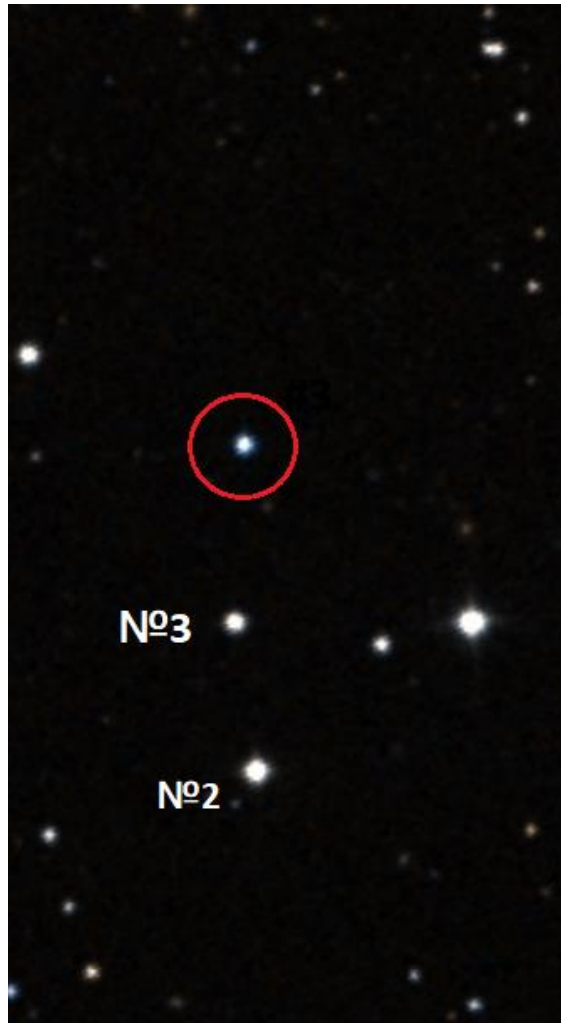
Special S5 0716+714



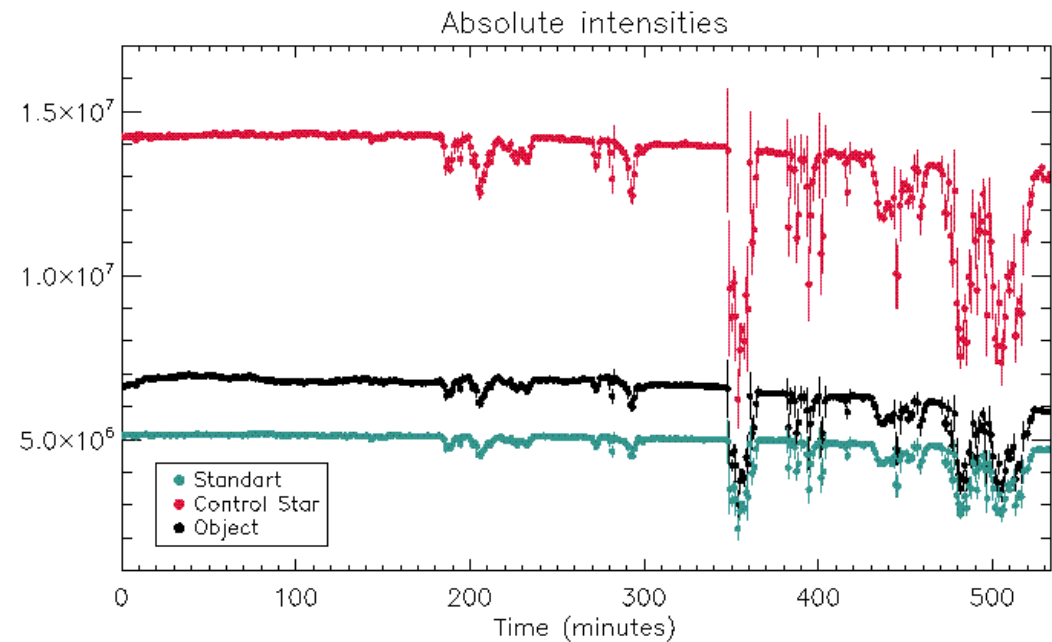
Blazar sample (Urry et al. 2000):
difference between the core and
the host $< 4^m$;
but for S5 0716+714 – **up to 7^m** .



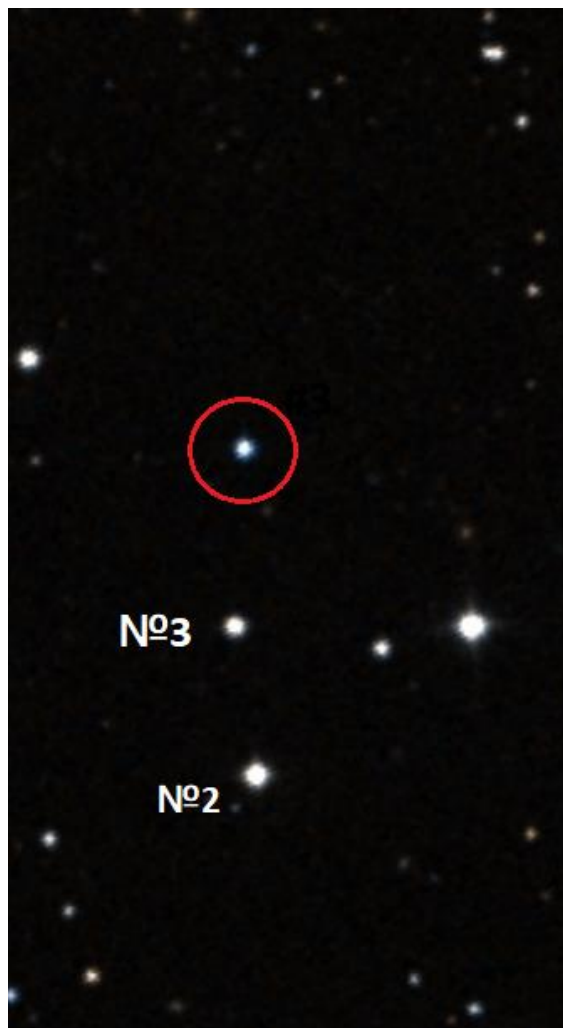
Observations



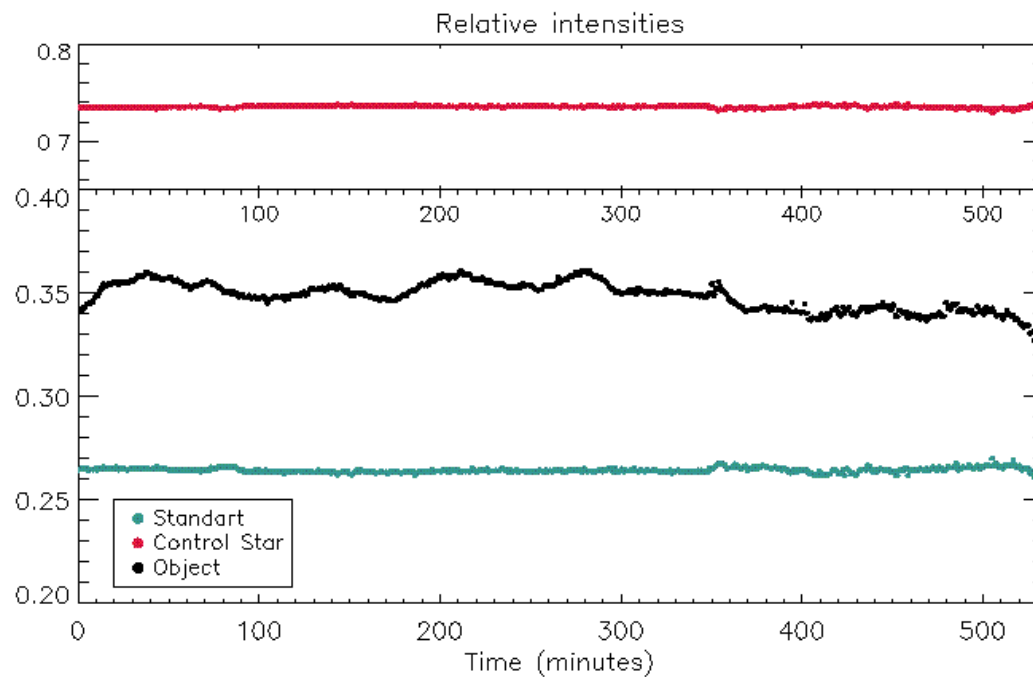
1. Simultaneous observations of the object and the star – photometric and zero-polarization standard (Amirkhanyan 2005).



Observations



1. Simultaneous observations of the object and the star – photometric and zero-polarization standard (Amirkhanyan 2005).



Observations

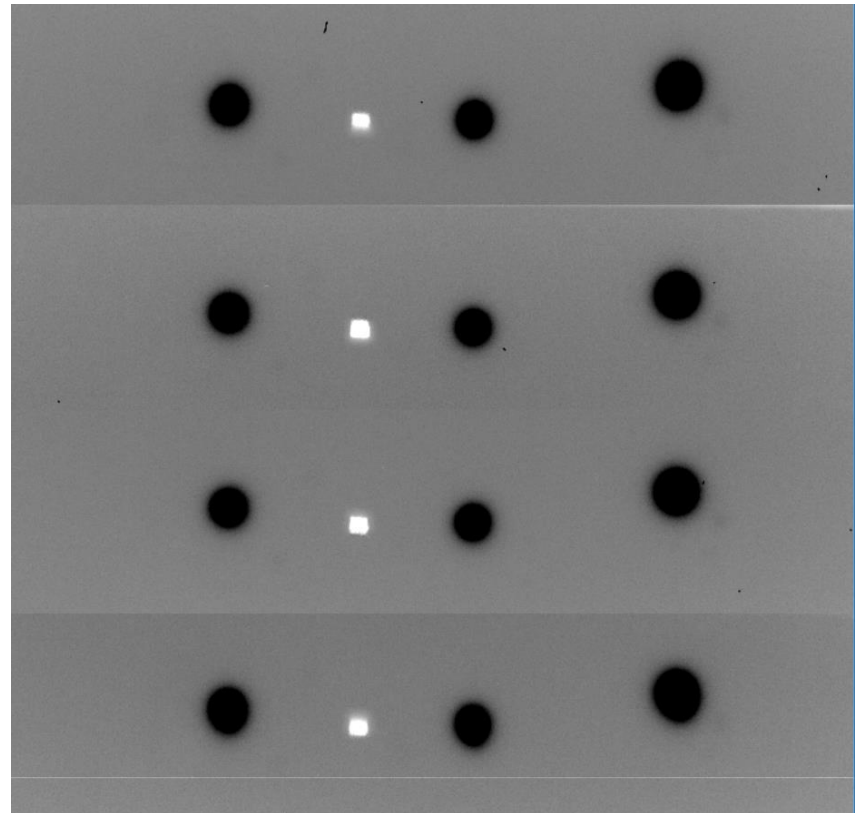
2. Double Wollaston prism \rightarrow simultaneous measurements of Q and U Stokes parameters (Afanasiev & Amirkhanyan 2012):

$$Q = \frac{I_0 - I_{90} D_Q}{I_0 + I_{90} D_Q}$$

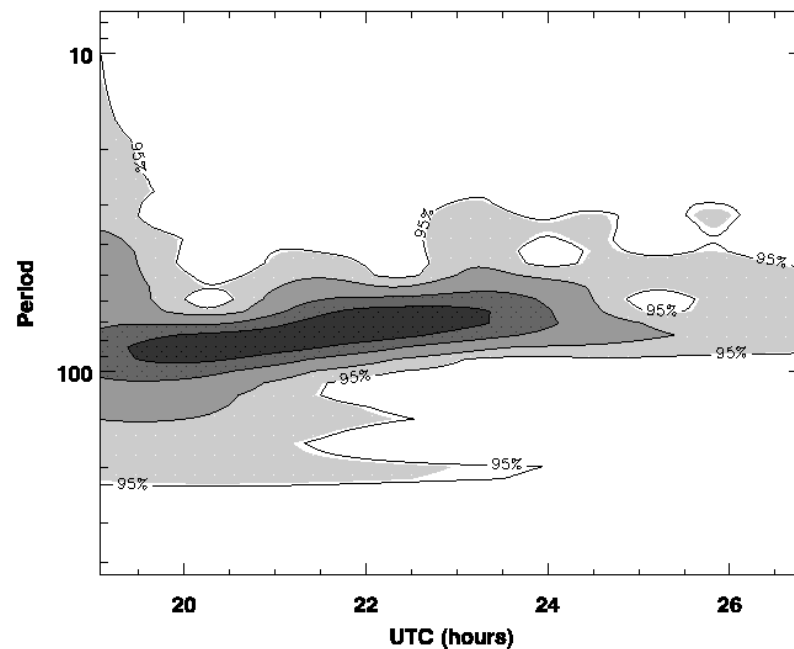
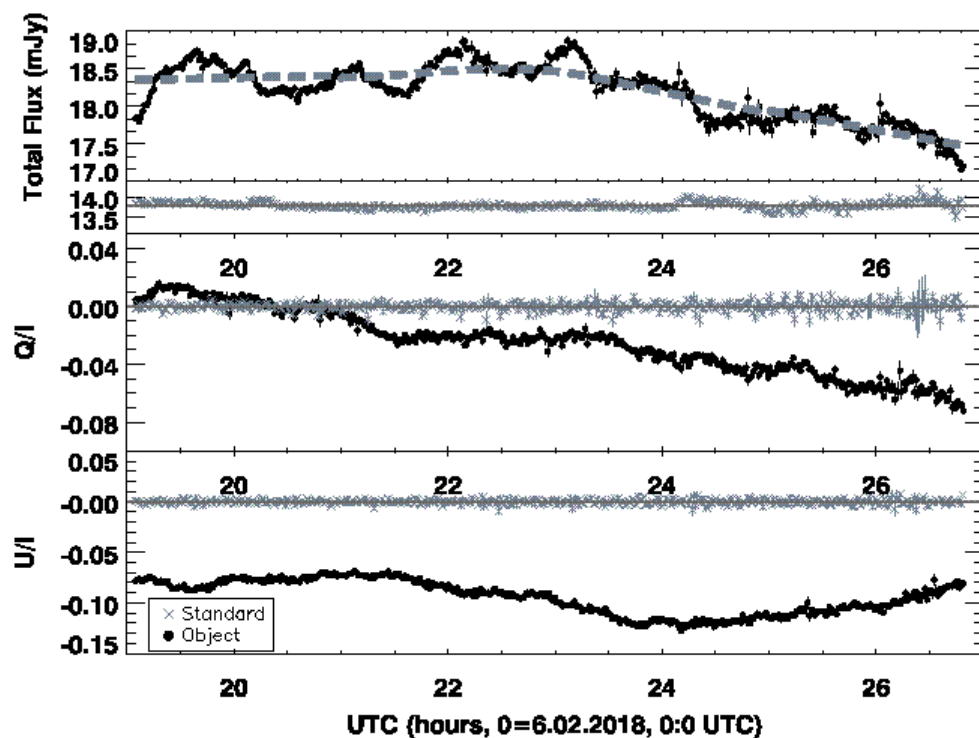
$$U = \frac{I_{45} - I_{135} D_U}{I_{45} + I_{135} D_U}$$

where $D_{Q,U}$ are the coefficients of polarization channel transmission:

$$D_Q = 1.036 \pm 0.015, D_U = 0.985 \pm 0.015.$$

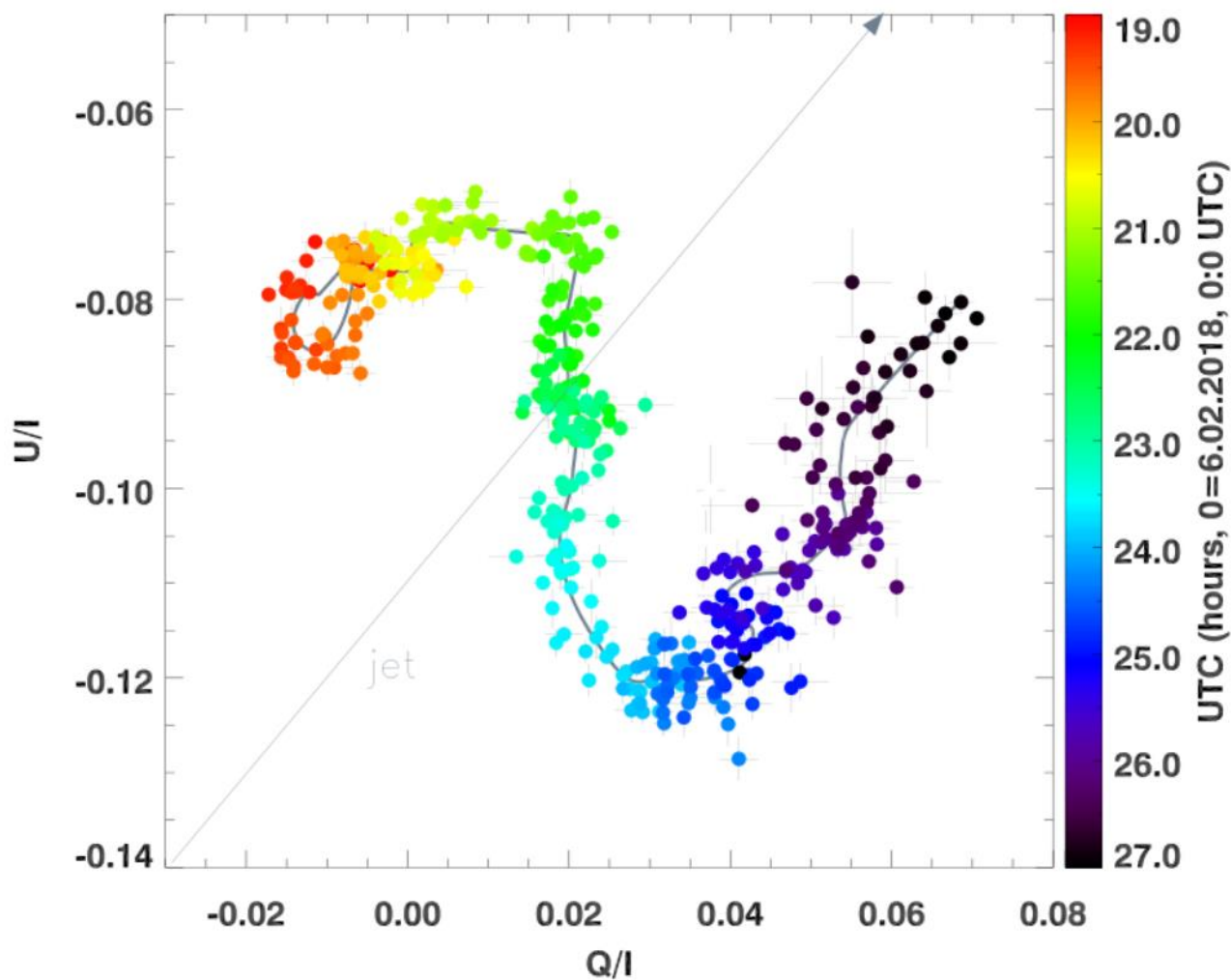


Observations – result



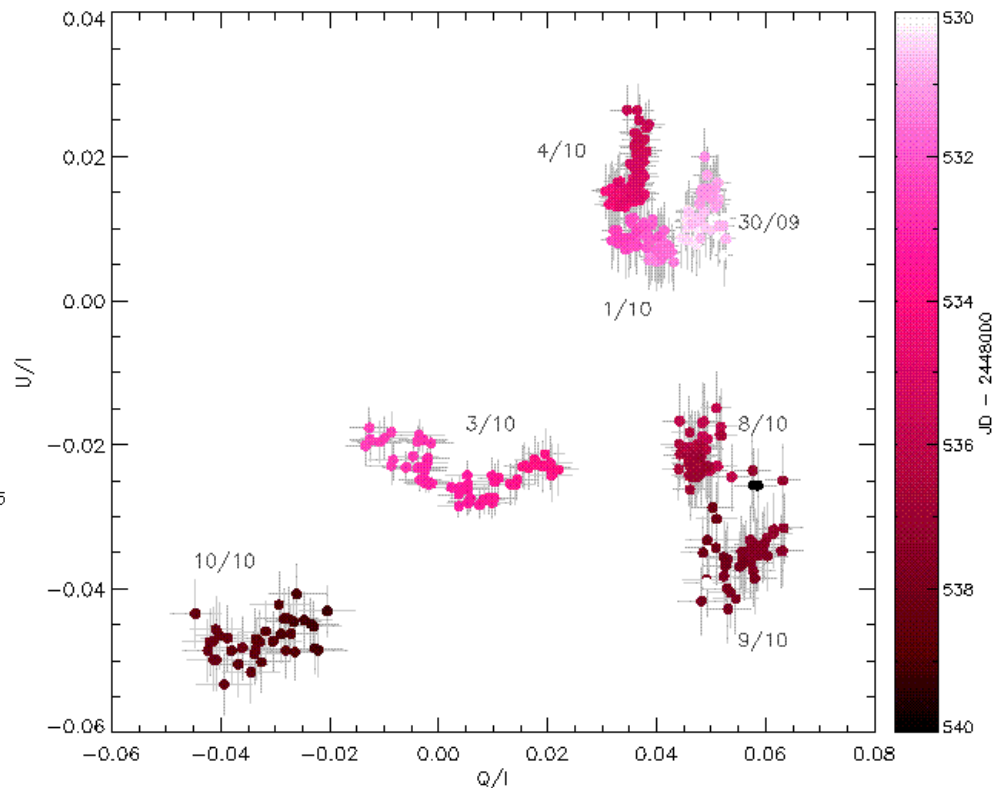
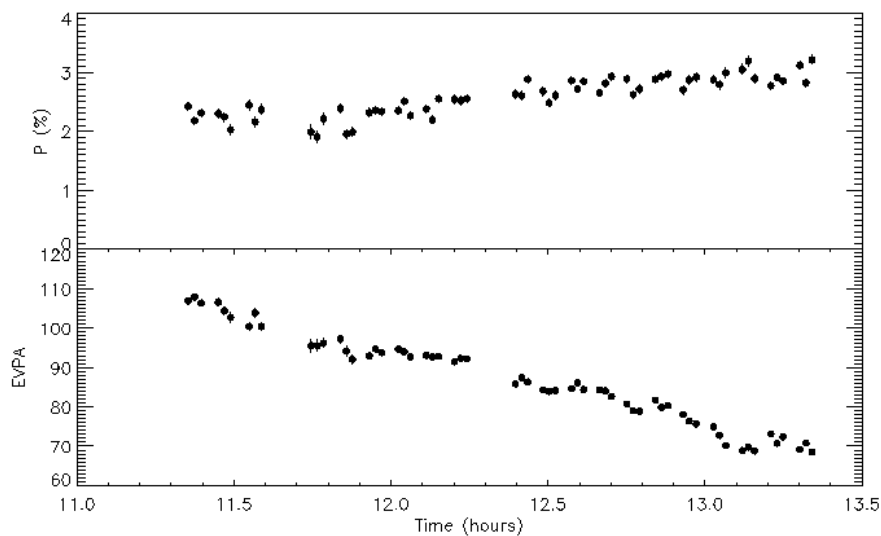
Variation period in total flux $\sim 77 \pm 10$ min.
 Photometric accuracy – 0.005^m.

Observations – result



The polarization vector direction switch – **1.5-3 hours**.
Polarimetric accuracy – 0.1%.

Monitoring on 6-m BTA – 1991/1994

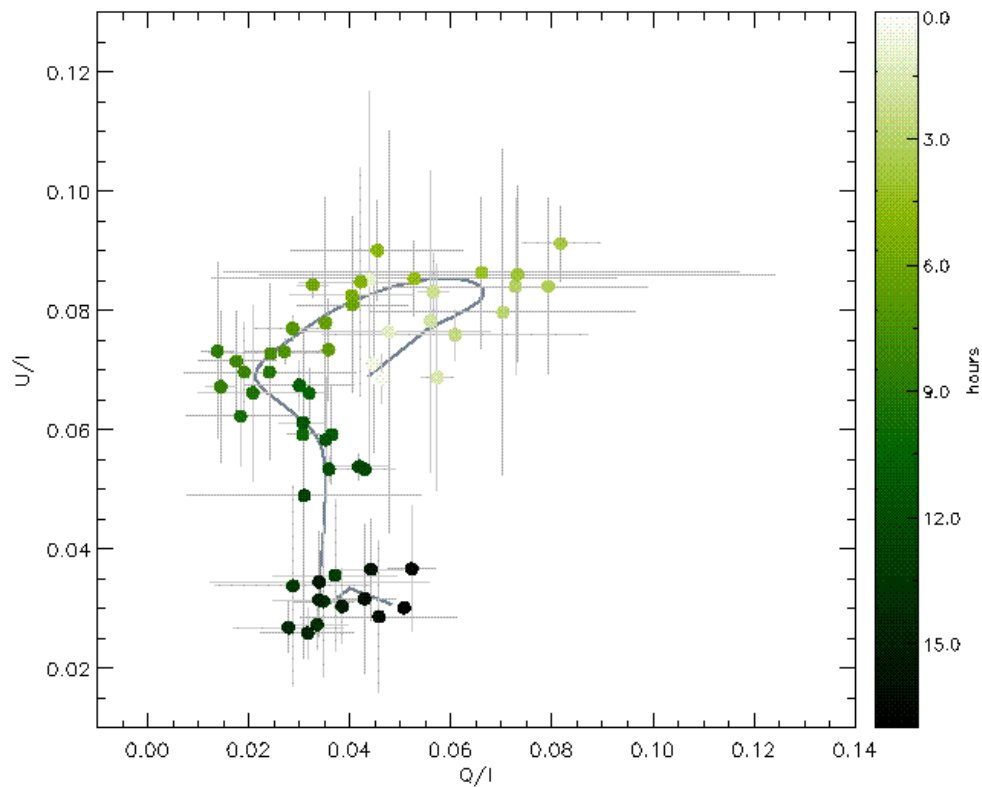
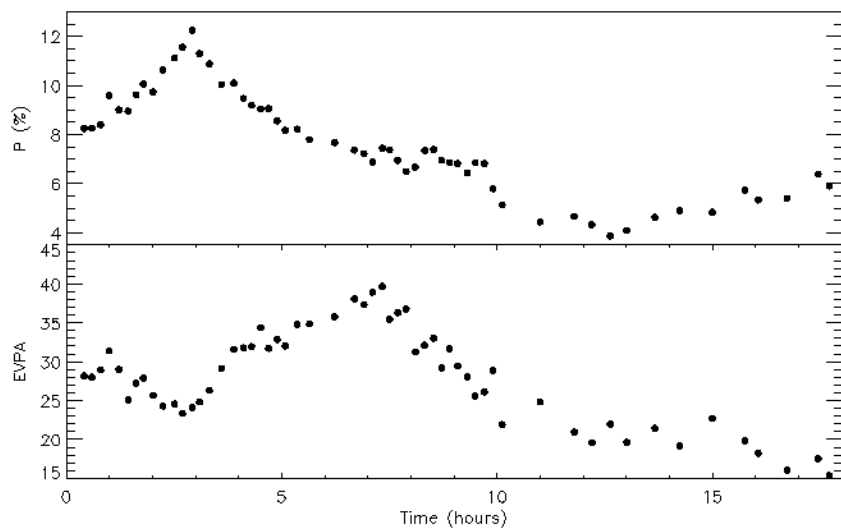


(Impey et al. 2000)

Temporal resolution: ~ 1 min.

Accuracy: 0.2-0.4%.

WEBT campaign – microflash 2014

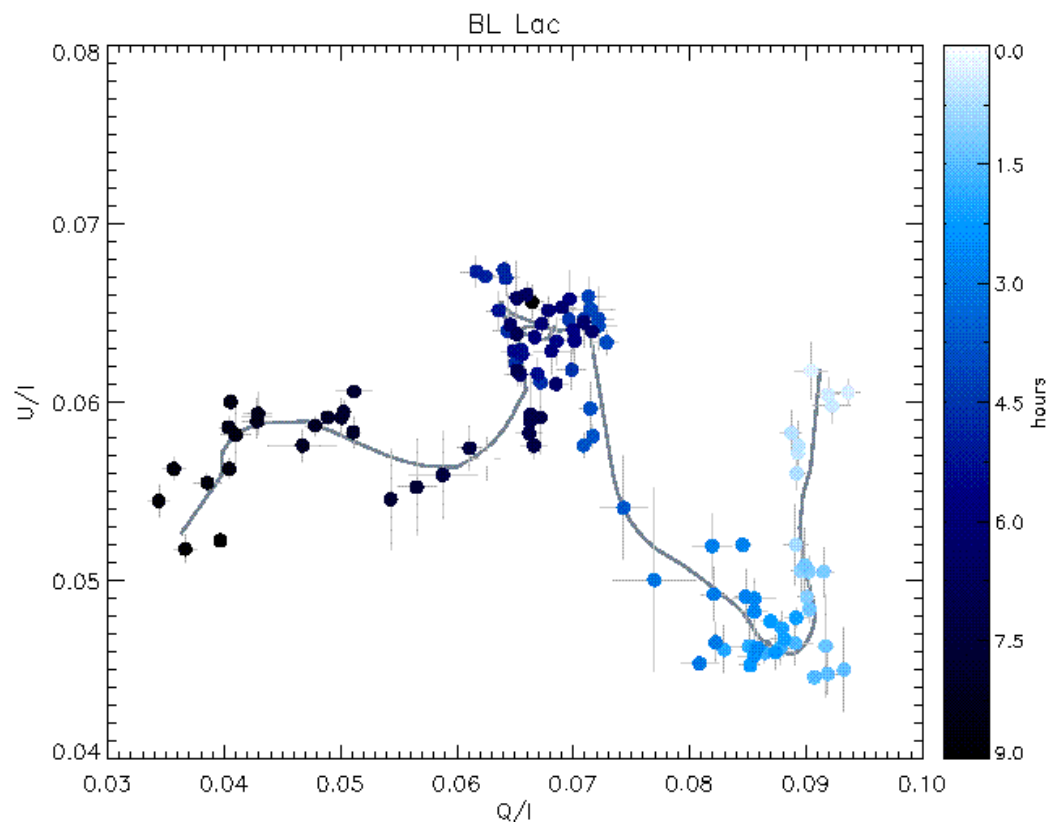
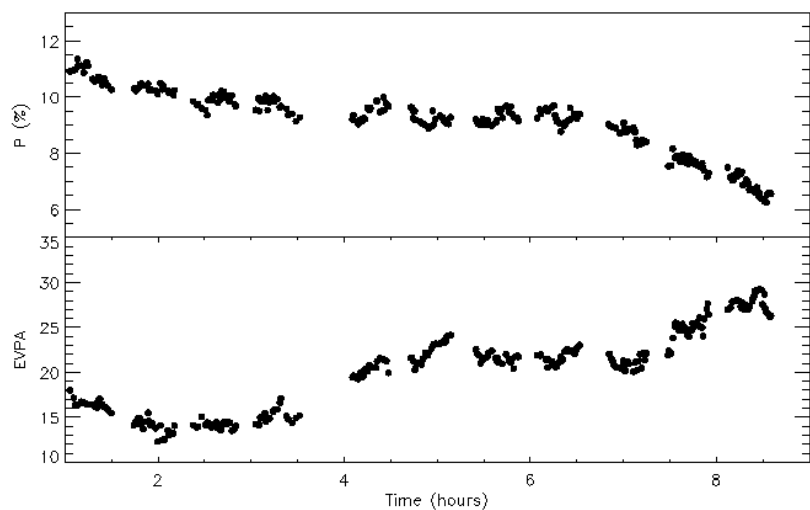


(Bhatta et al. 2015, 2016)

Temporal resolution : ~ 20 min.

Accuracy: 2-10%.

Rapid variations of BL Lac



(Covino et al. 2015)

Temporal resolution : ~ 1 -2 min.

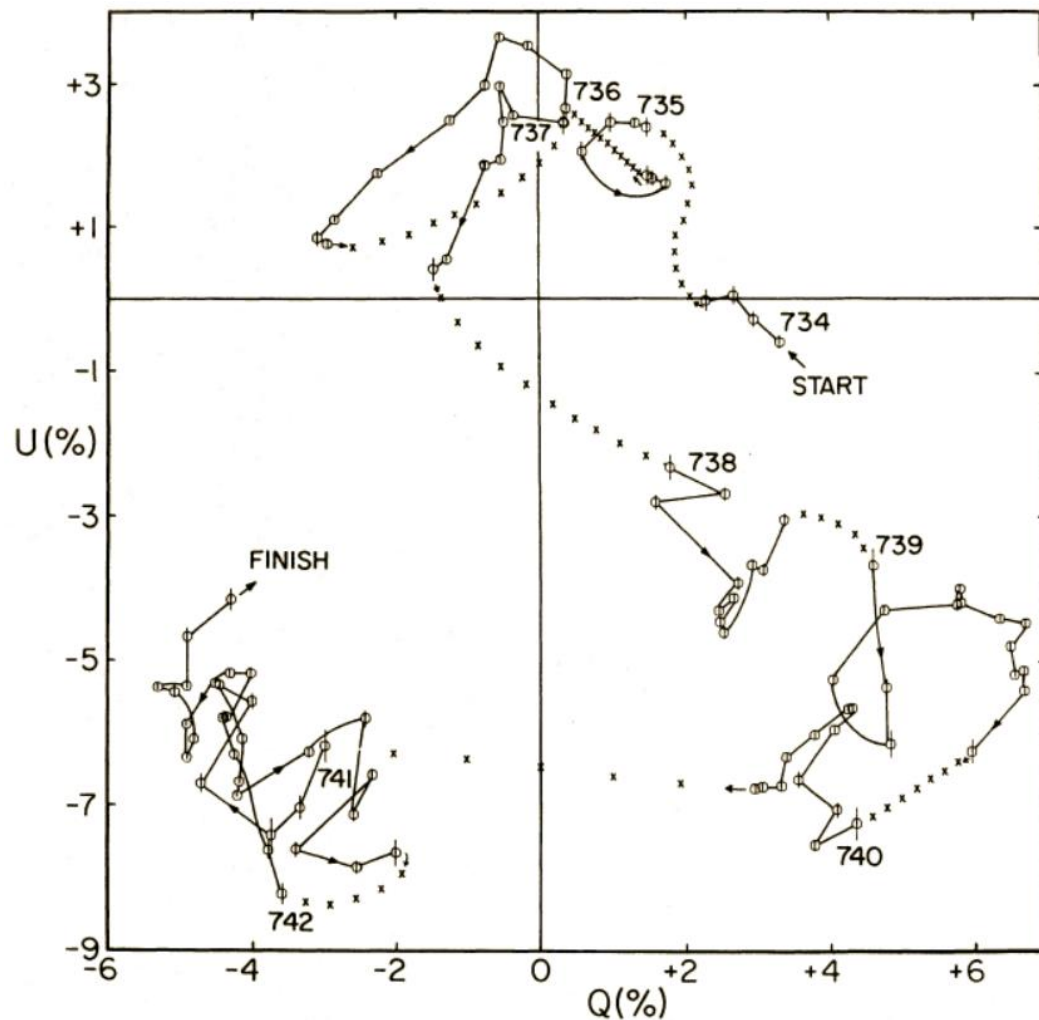
Accuracy: 0.2-0.3%.

Rapid variations of BL Lac

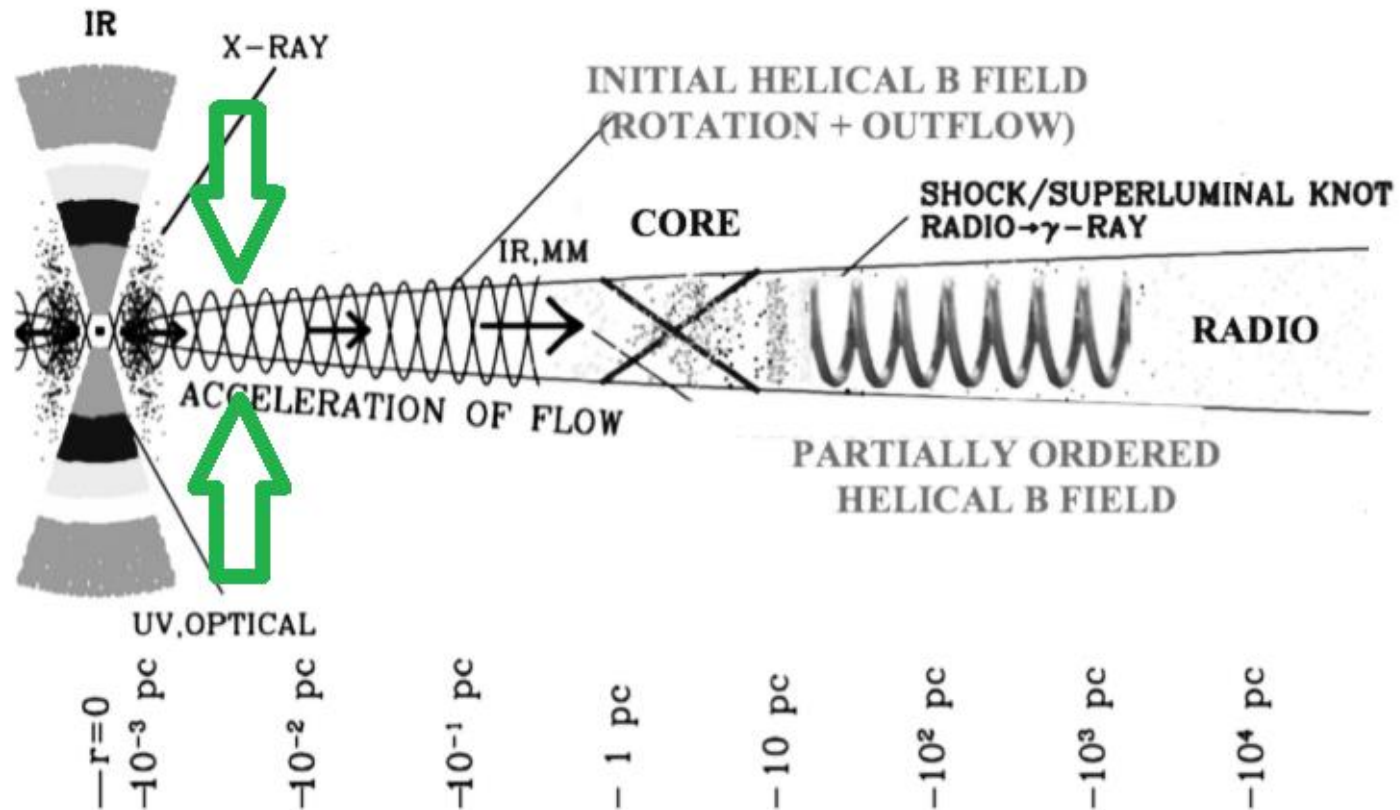
(Moore et al. 1982)

Temporal resolution : ~ 10 min.

Accuracy: 0.3-0.4%.



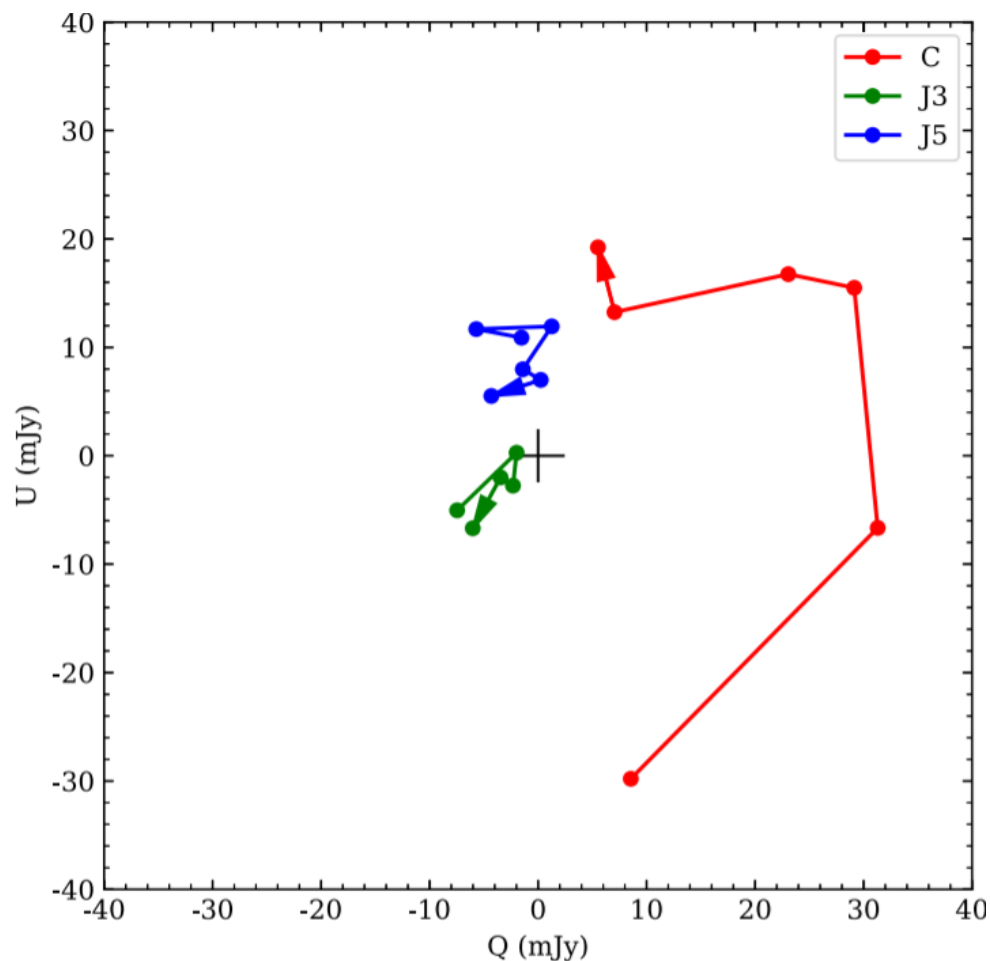
Polarization model



(Marscher 2005)

Helical magnetic field at $<10^{-2}$ pc from the core.

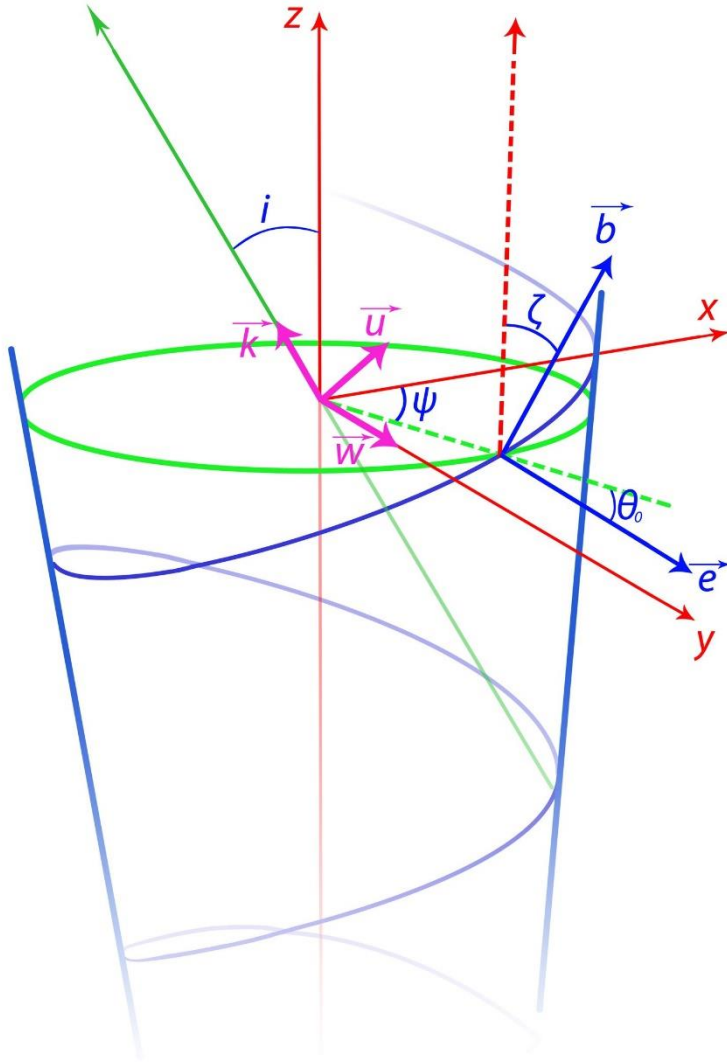
Polarization model



(Li et al. 2018)

Radio observations of CTA 102
in polarized light →
Suggestion of the helical
plasma trajectory in jet.

Polarization model



(Steffan 1995, Li et al. 2018):

$$\rho = f \sqrt{1 + \left(\frac{at + b}{f}\right)^2}$$

$$\varphi = \frac{1}{\sin\theta} \left[\arctan\left(\frac{at + b}{f}\right) - \arctan\left(\frac{b}{f}\right) \right]$$

$$z = \frac{\rho - \rho_0}{\tan\theta}$$

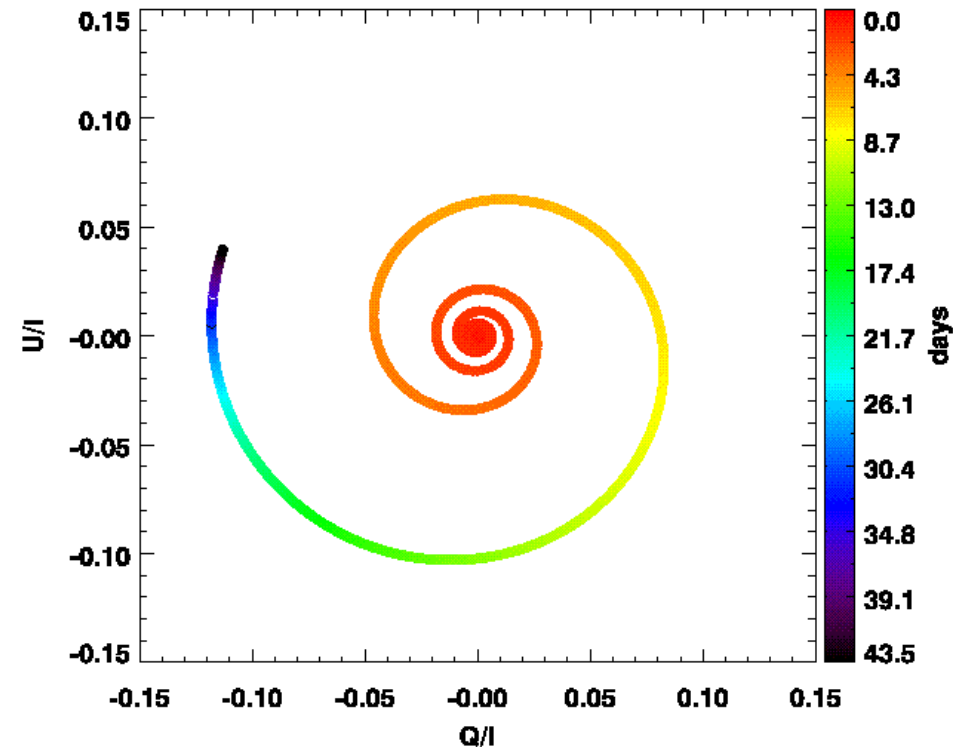
where the next coefficients are used:

$$a = \beta \sin\theta, \quad b = \sqrt{\rho_0^2 - f^2}, \quad f = \frac{j}{b}$$

where $\beta = v/c$ is the velocity in units of speed of light, ρ_0 is the cylindrical distance, $j = L/E_{kin} c$ is the angular momentum.

Polarization model

Kinematic parameters		Value
Inclination angle ¹	i	5°
Half-opening angle of the cone ¹	θ	1.5°
Physical speed of the optical jet ²	β	$0.999c$
Cylindrical distance	ρ_0	$5 \cdot 10^{-5}$ pc
Angular momentum	j	$0.9\beta\rho_0$
Maximum PD ³	P_{max}	0.3



¹ (Pushkarev et al. 2009)

² (Butuzova 2018)

³ (Larionov et al. 2013)

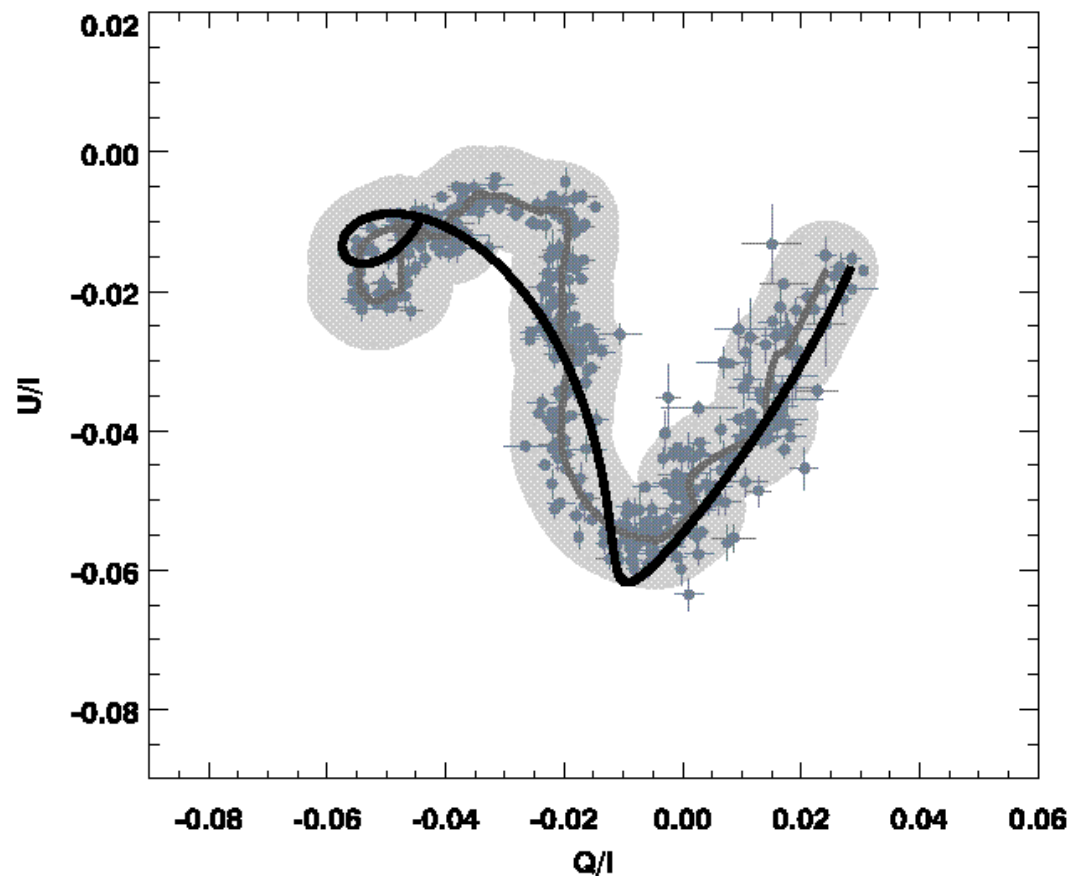
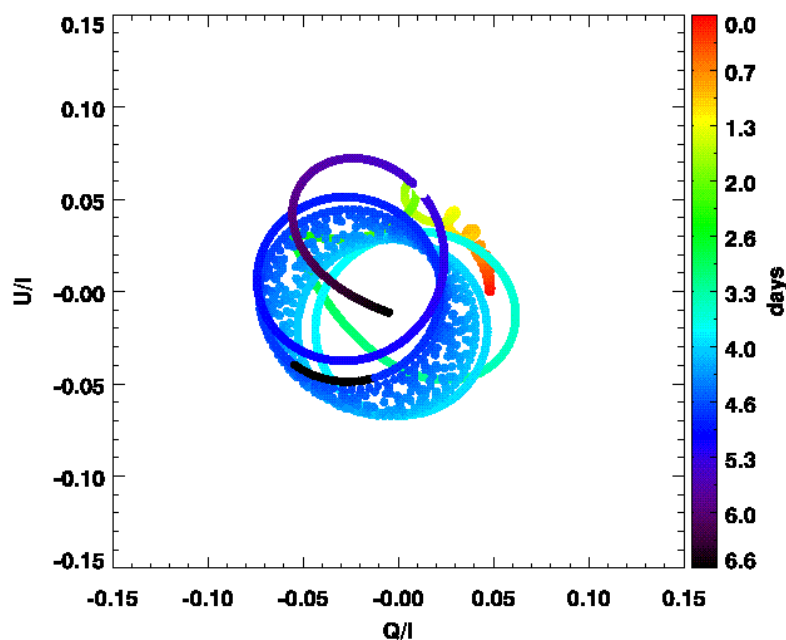
Polarization model – add precession

Kinematic parameters

Value

Distance from the precession axis ω $0.7 \cdot 10^{-3} \text{ pc}$

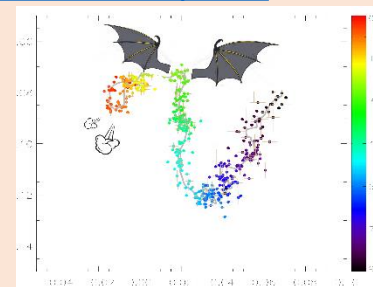
Precession period T 15 days



Conclusions

- We found the variability of the total ($\Delta=0.04^m$) and polarized ($\Delta=7\%$) fluxes on a time-scale **~ 1.5 hours**;
- We discovered the specific pattern of the polarization vector on the QU -plane – «arches» and «loops»;
- The estimation of the linear size of the field identifying with the emitting region – **$1.5 \cdot 10^{-5}$ pc, or 10 a.u.** at $\sim 10^{-3}$ pc from the central BH;
- The polarization vector rotations marks the magnetic field precessing with the **15 days** period;
- The similar pattern was found in other papers and also for BL Lac.

MNRAS, Volume 482, Issue 4, 1 February 2019, Pages 4322– 4328, <https://doi.org/10.1093/mnras/sty2943>



Proper motion S5 0716+714

