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

Elena Shablovinskaya, Victor Afanasiev
Special Astrophysical Observatory of RAS

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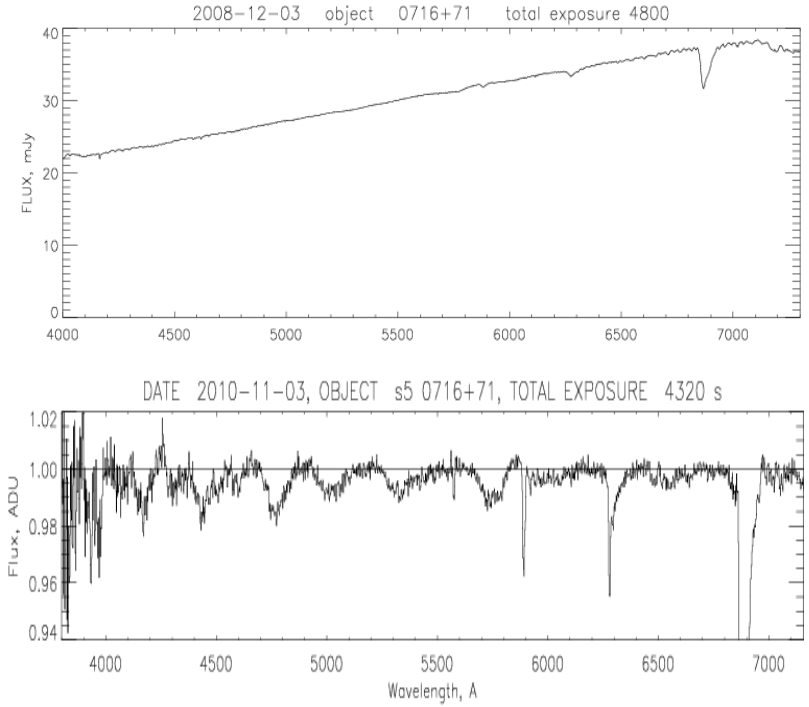
Special S5 0716+714

Redshift z - ?

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



- No evidence of the host galaxy.

» (Urry et al. 2000) – *HST* survey → $m > 20.0^m \rightarrow z > 0.5$

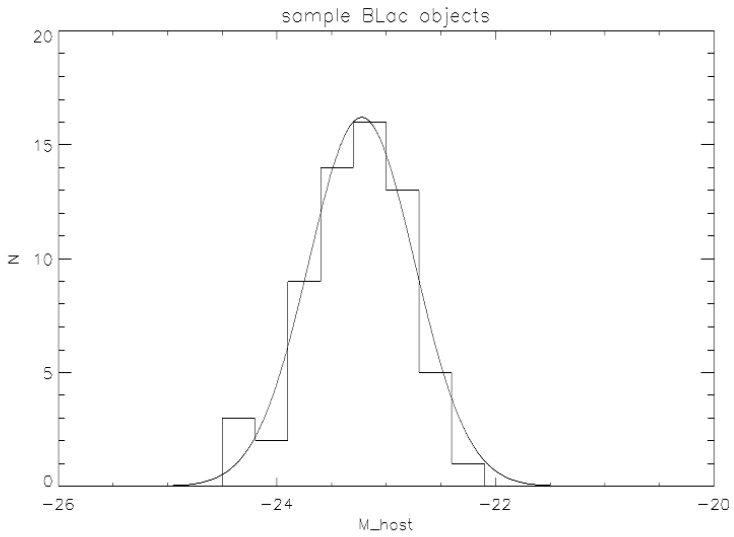
» (Stickel et al. 1993) → $z \approx 0.26$

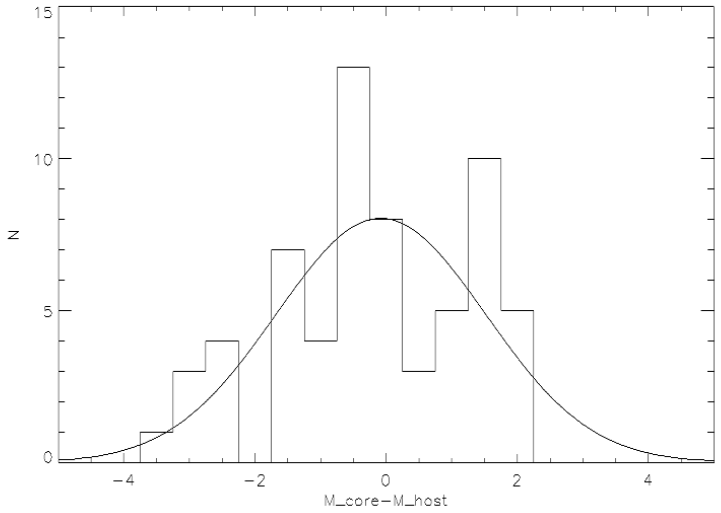
» (Bychkova et al. 2006) → $z = 0.3$

» (Nilsson et al. 2008) → $z = 0.3$

» (Stadnik & Romani 2014) → $z = 0.127$

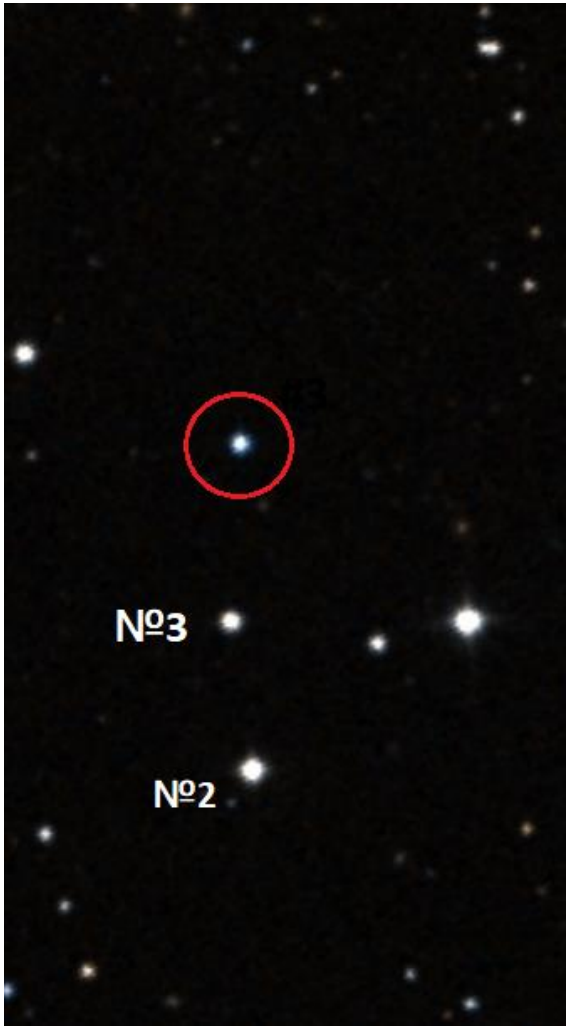
Special S5 0716+714



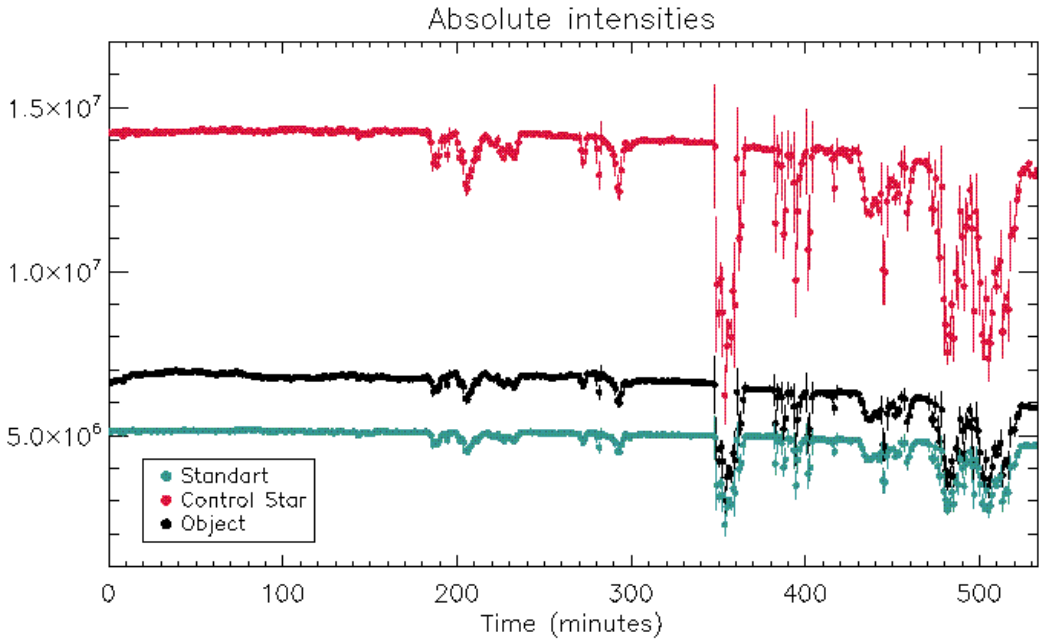


Blazar sample (Urry et al. 2000): difference between the core and the host $< 4^m$;
but for S5 0716+714 – up to 7^m.

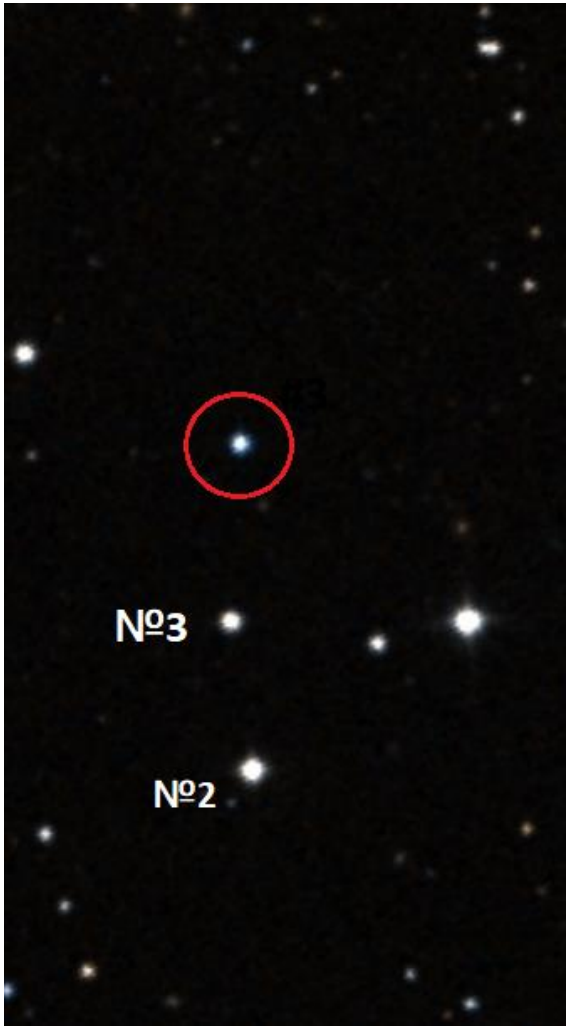
Observations



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



Observations



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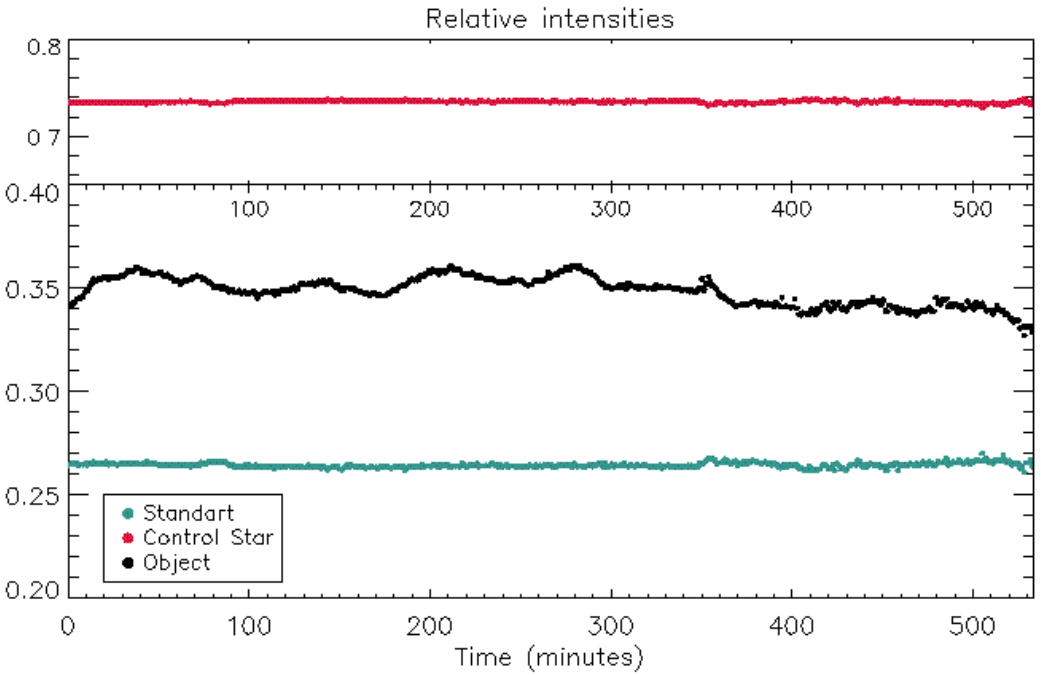


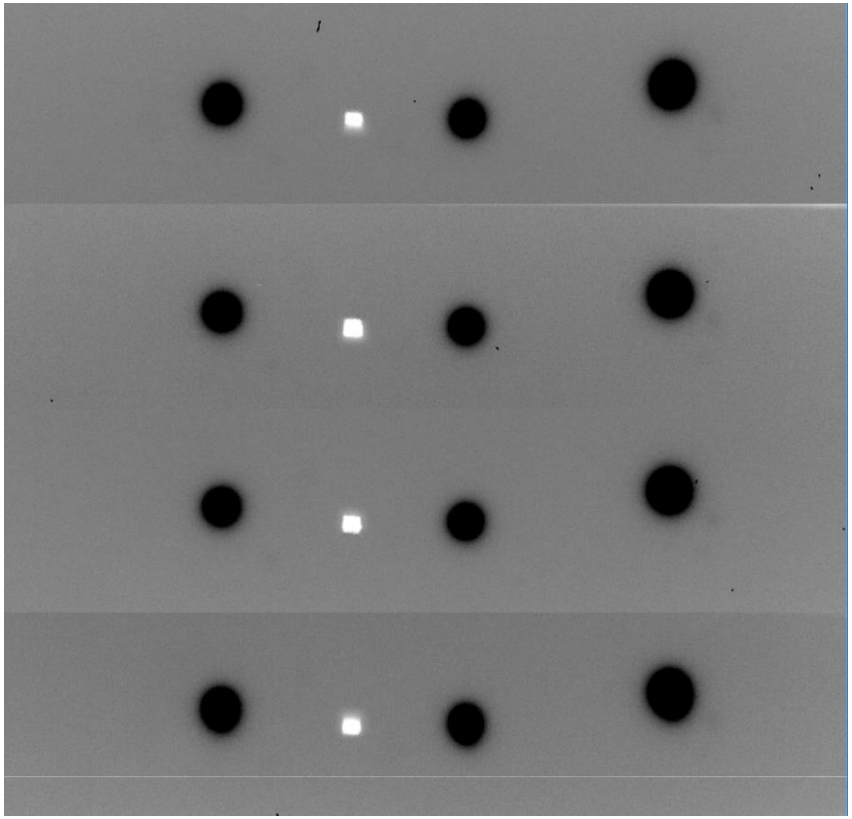
Observations

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

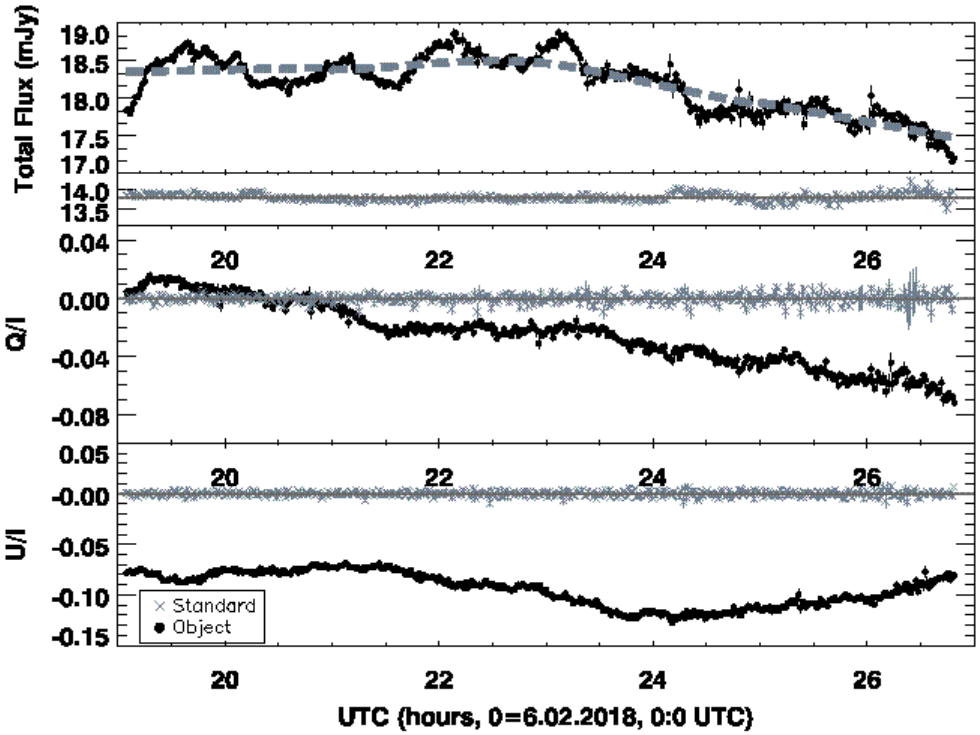
$$Q = \frac{I_0 - I_{90} D_Q}{I_0 + I_{90} D_Q}$$

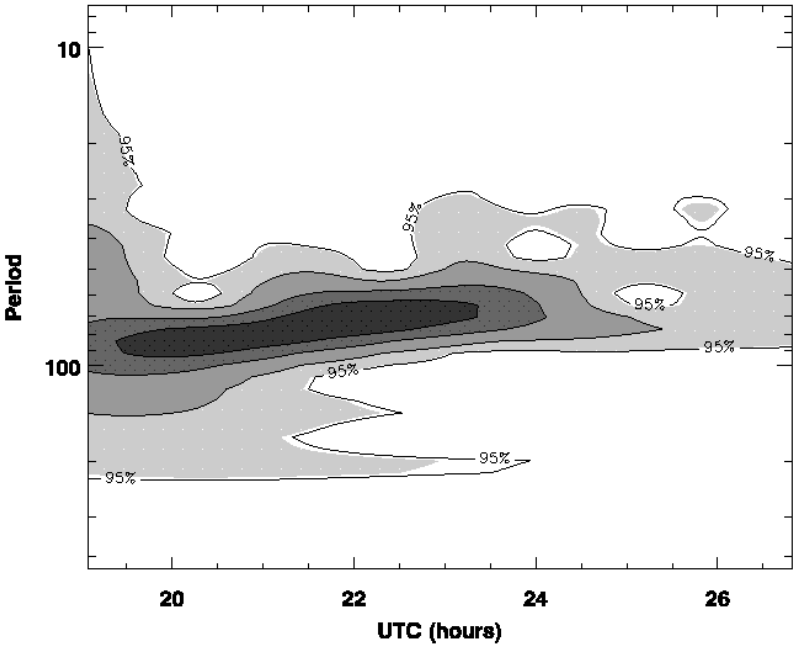
$$U = \frac{I_{45} - I_{135} D_U}{I_{45} + I_{135} D_U}$$

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

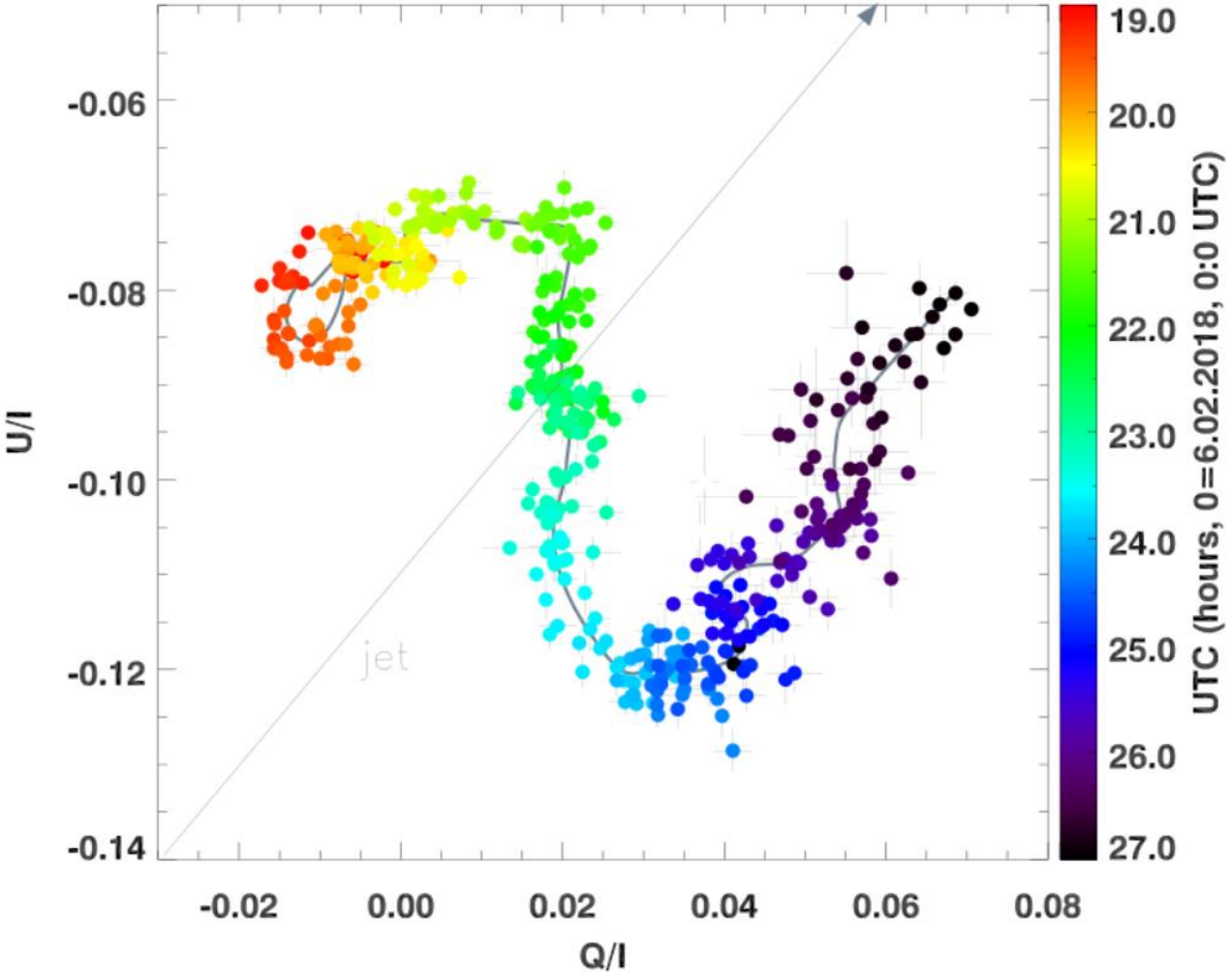




Variation period in total flux $\sim 77 \pm 10$ min.

Photometric accuracy – 0.005^{m}.

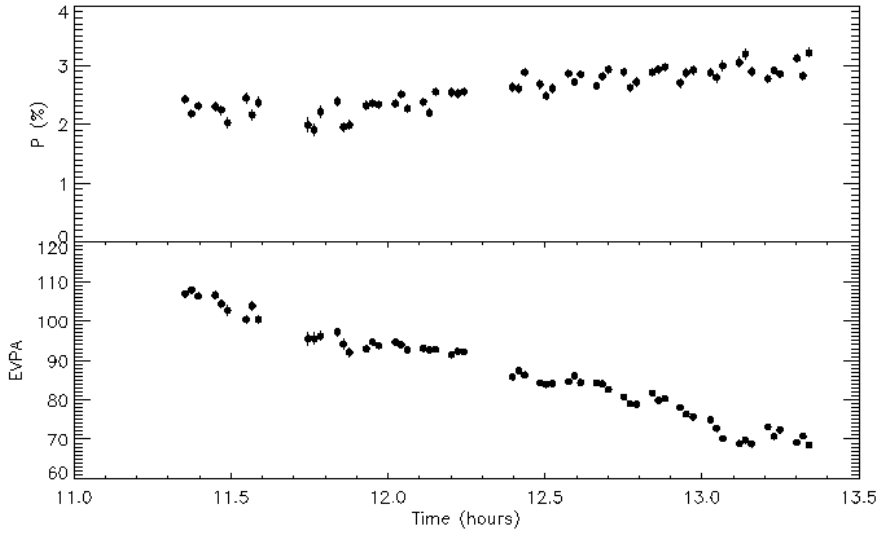
Observations – result

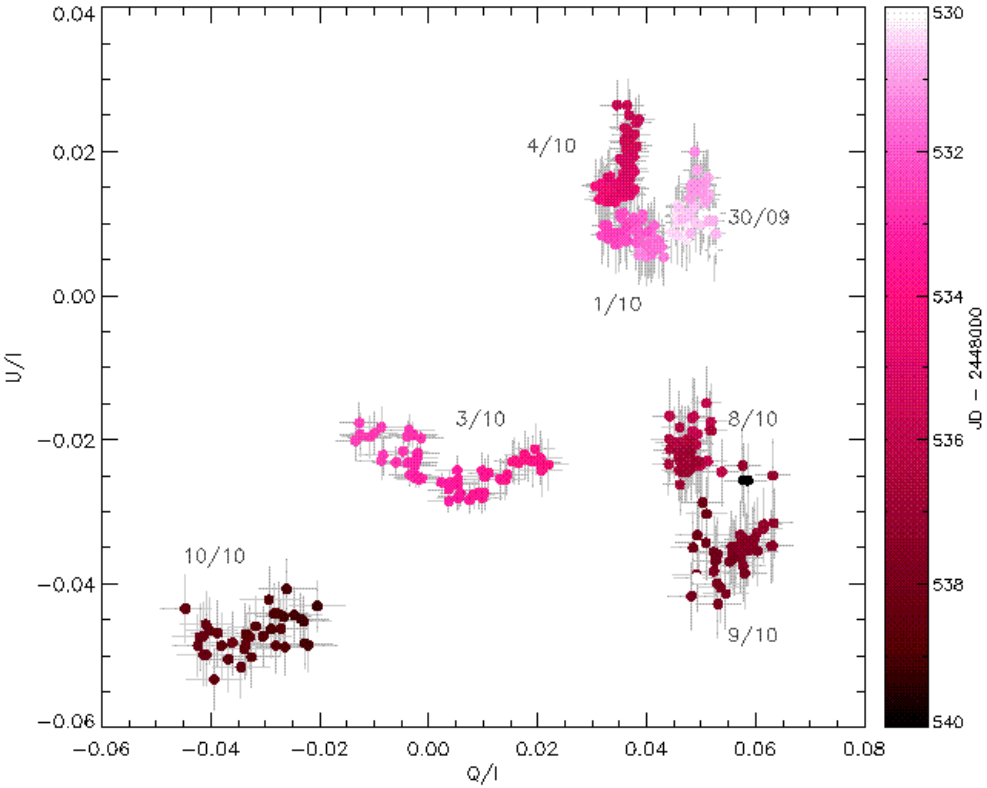


The polarization vector direction switch – 1.5-3 hours.

Polarimetric accuracy – 0.1%.

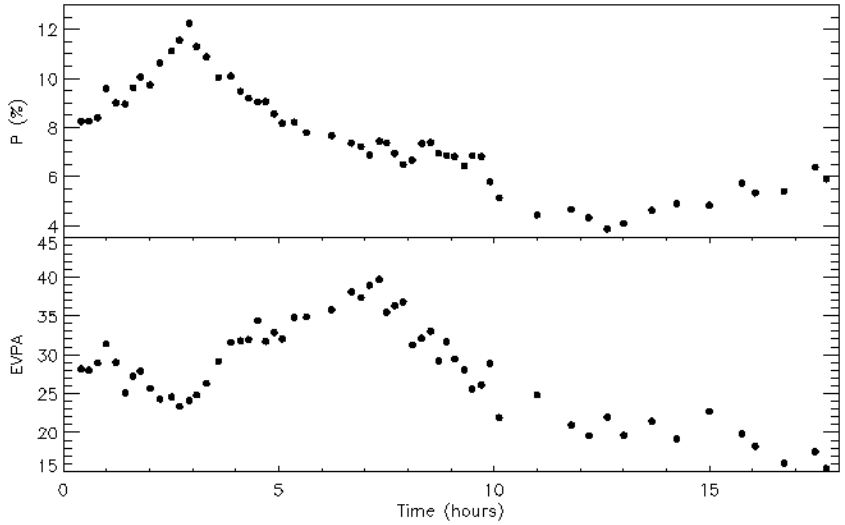
Monitoring on 6-m BTA – 1991/1994

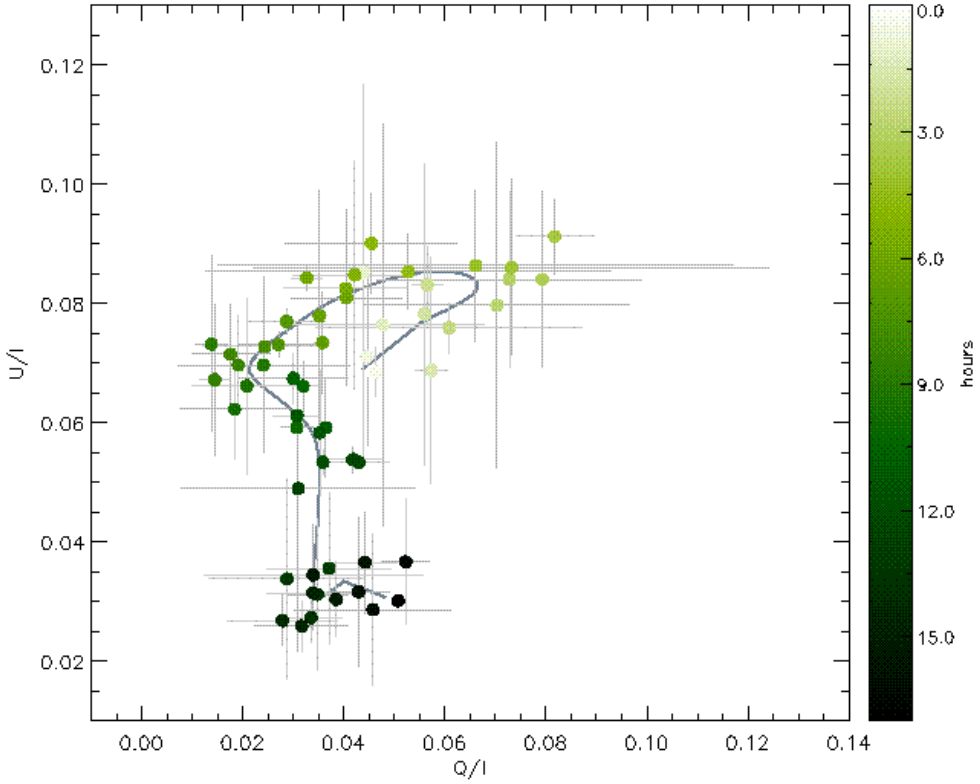




(Impey et al. 2000)
Temporal resolution: ∼1 min.
Accuracy: 0.2-0.4%.

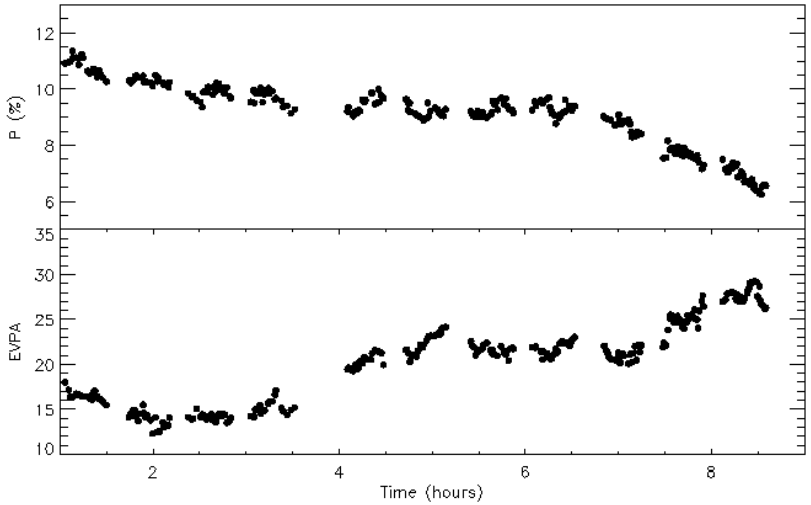
WEBT campaign – microflash 2014

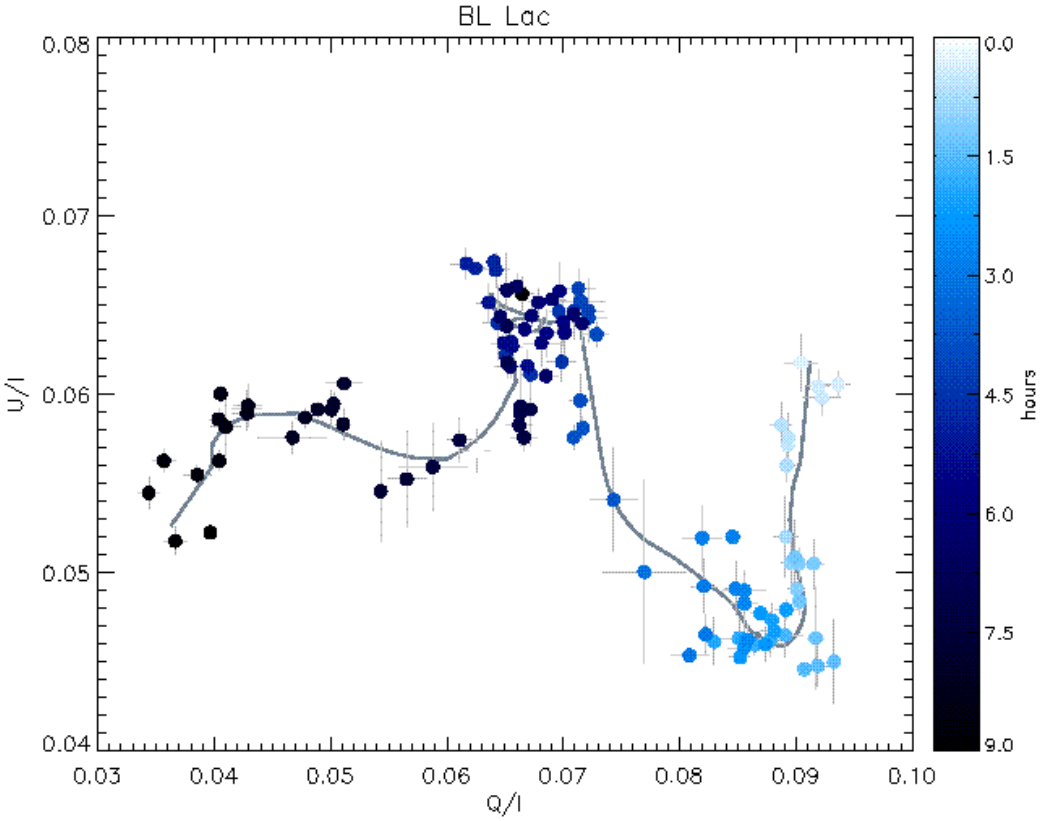




(Bhatta et al. 2015, 2016)
Temporal resolution : ~20 min.
Accuracy: 2-10%.

Rapid variations of BL Lac

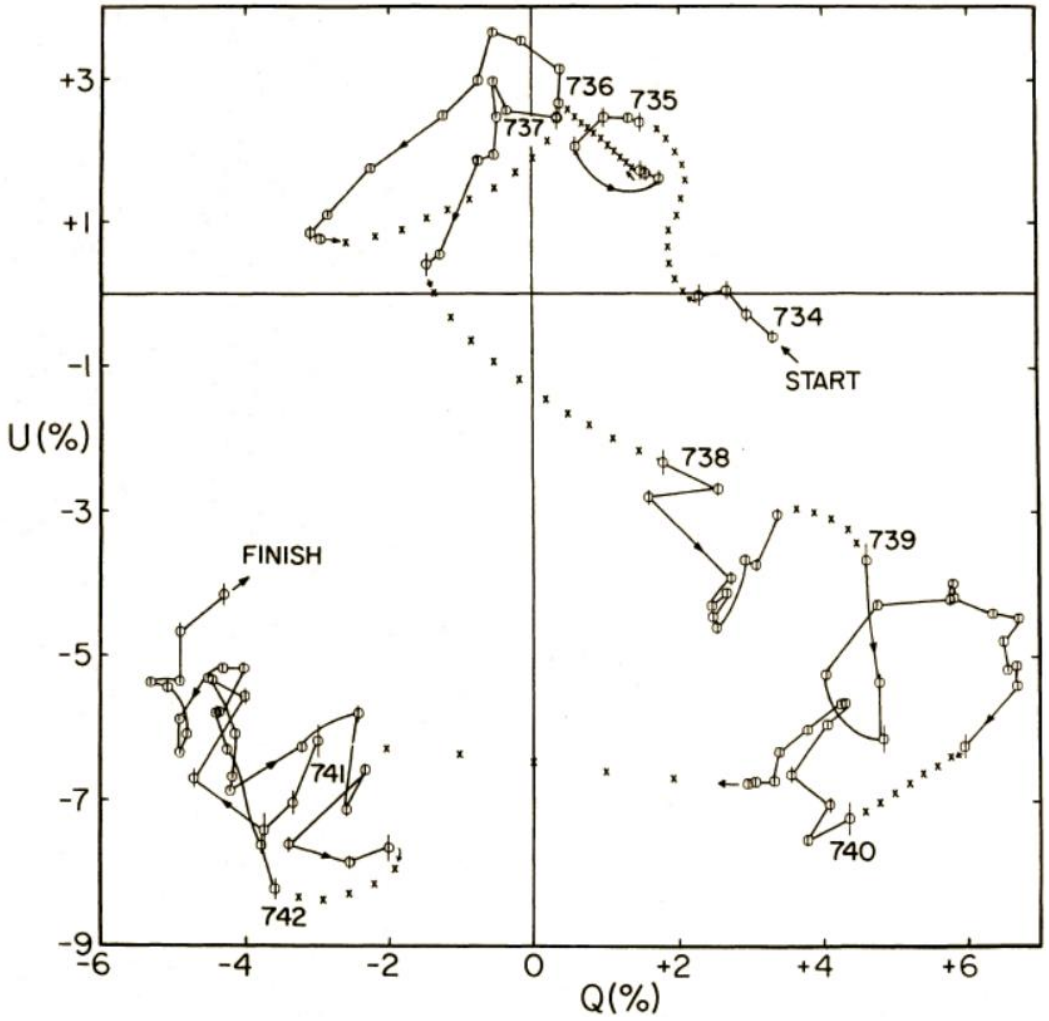




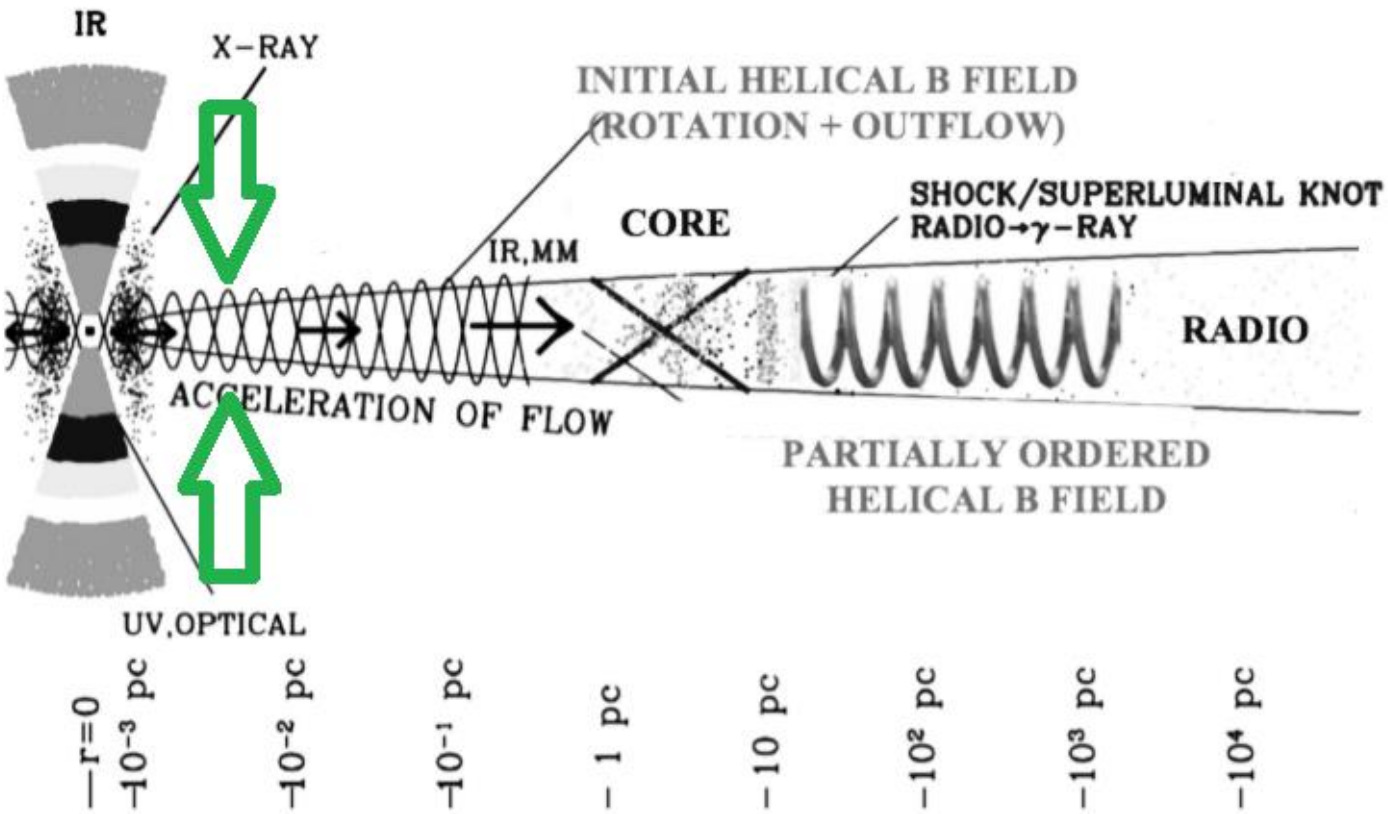
(Covino et al. 2015)
Temporal resolution : ~1-2 min.
Accuracy: 0.2-0.3%.

Rapid variations of BL Lac

(Moore et al. 1982)
Temporal resolution : ∼10 min.
Accuracy: 0.3-0.4%.



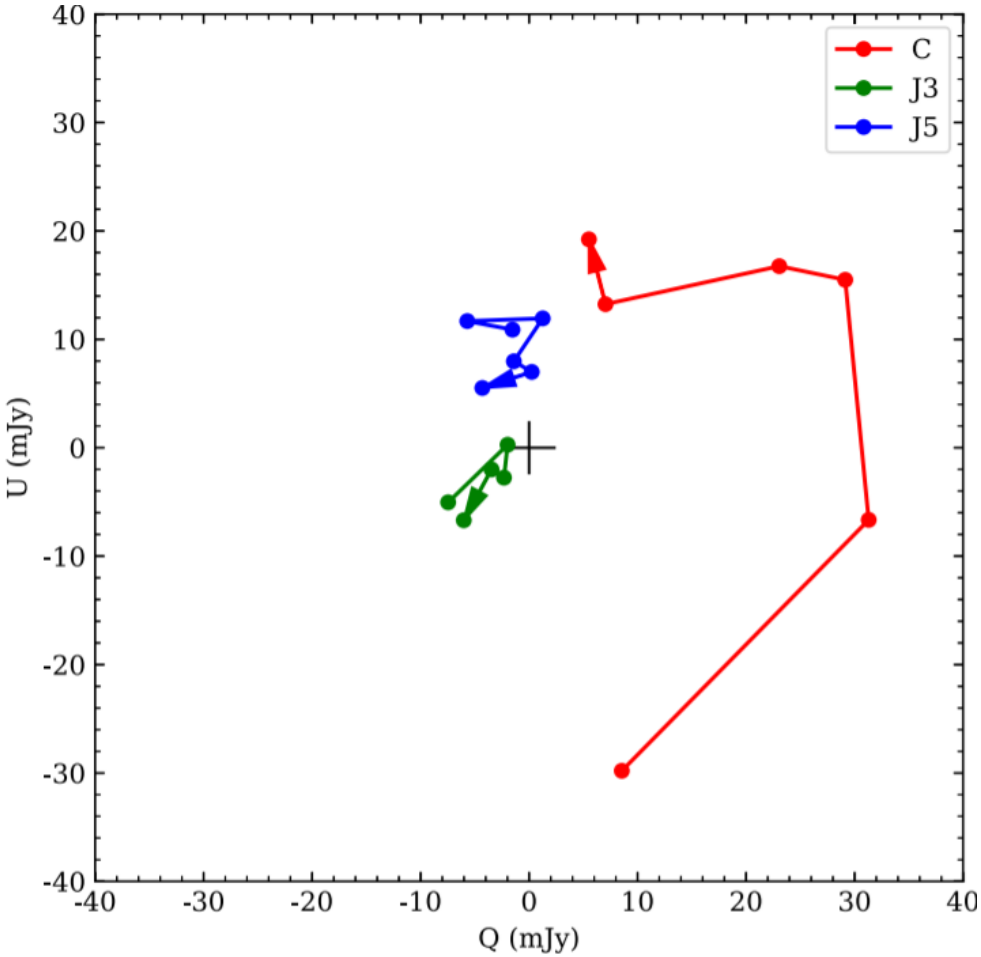
Polarization model



(Marscher 2005)

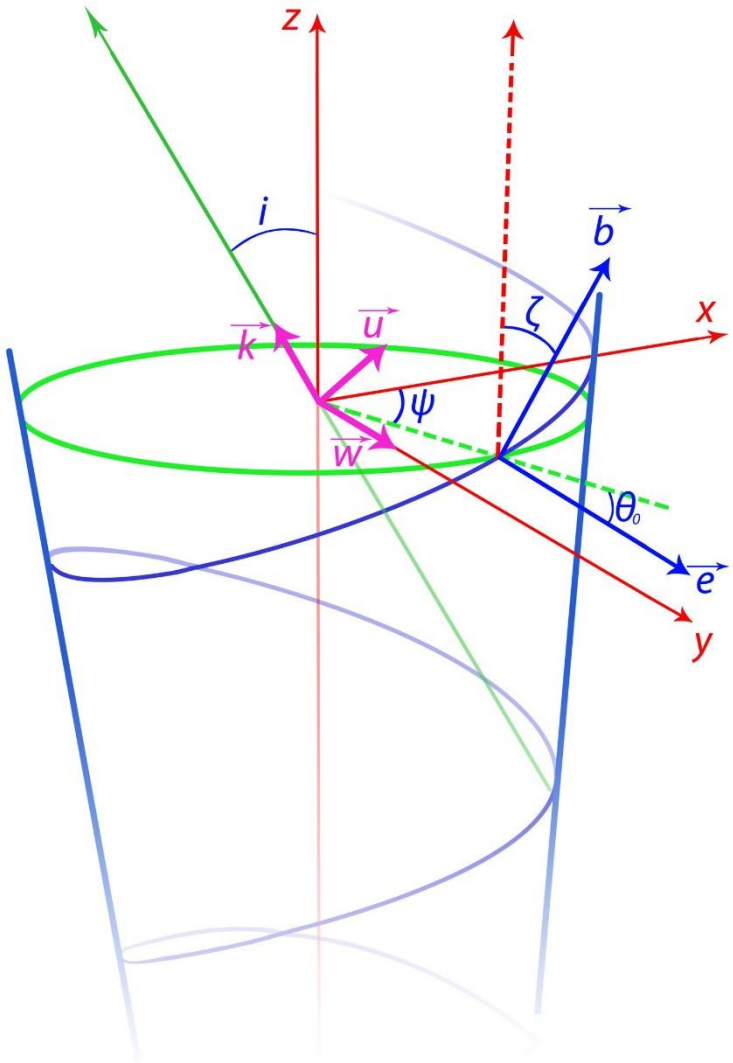
Helical magnetic field at $<10^{-2}$ pc from the core.

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):

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

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

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

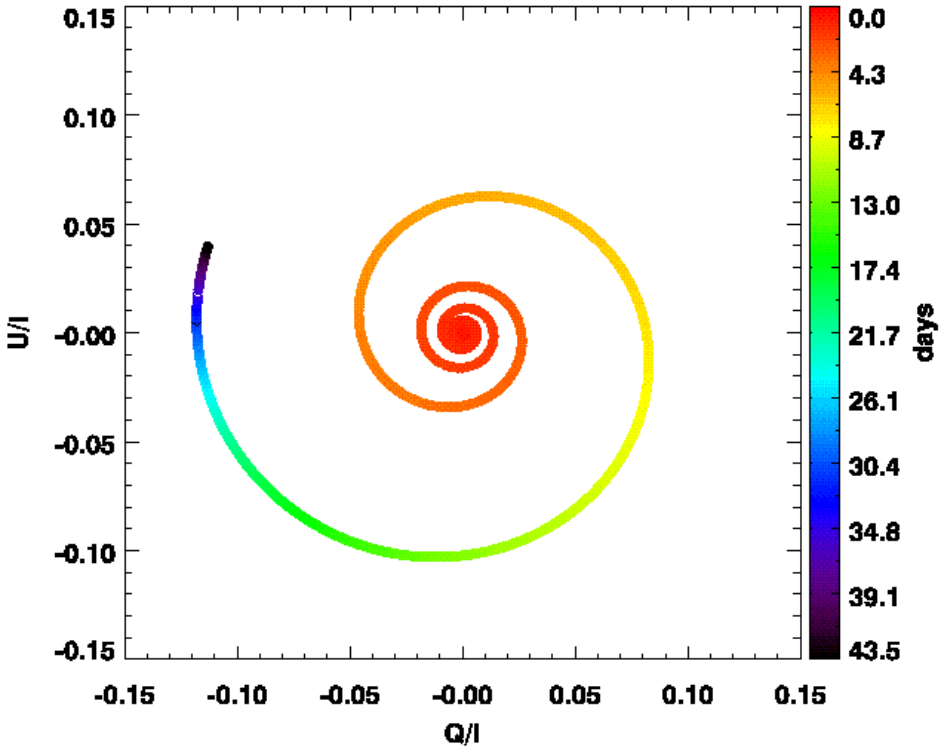
where the next coefficients are used:

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

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

Polarization model

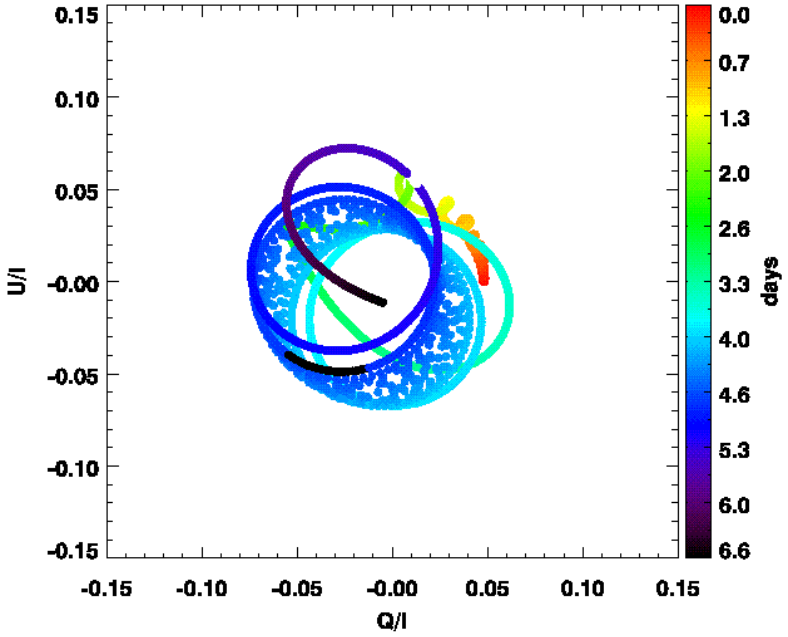
Kinematic parameters		Value
Inclination angle[1]	i	$5°$
Half-opening angle of the cone[1]	θ	$1.5°$
Physical speed of the optical jet[2]	β	$0.999c$
Cylindrical distance	ρ_0	$5 \cdot 10^{-5}$ pc
Angular momentum	j	$0.9\beta\rho_0$
Maximum PD[3]	P_{max}	0.3

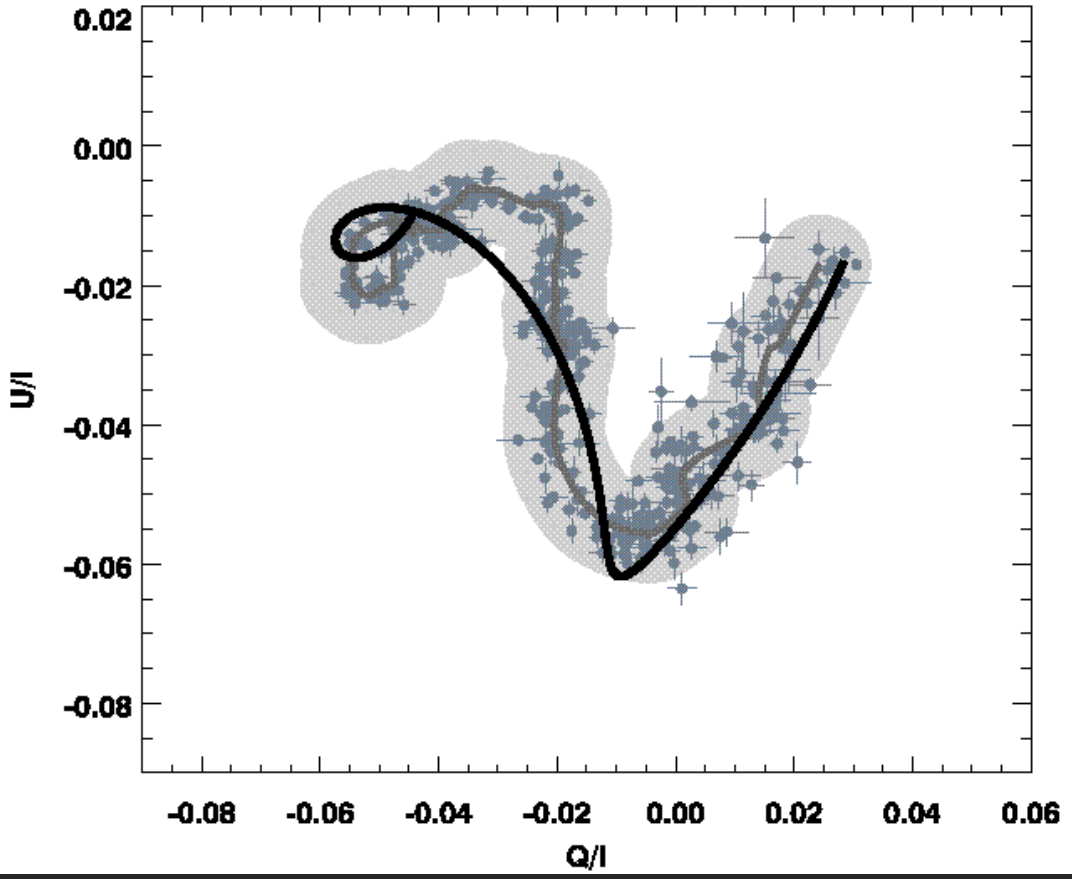


[1] (Pushkarev et al. 2009)
[2] (Butuzova 2018)
[3] (Larionov et al. 2013)

Polarization model – add precession

Kinematic parameters		Value
Distance from the precession axis	ω	$0.7 \cdot 10^{-3}$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 patter 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 ~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.

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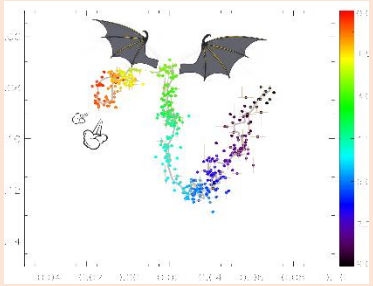

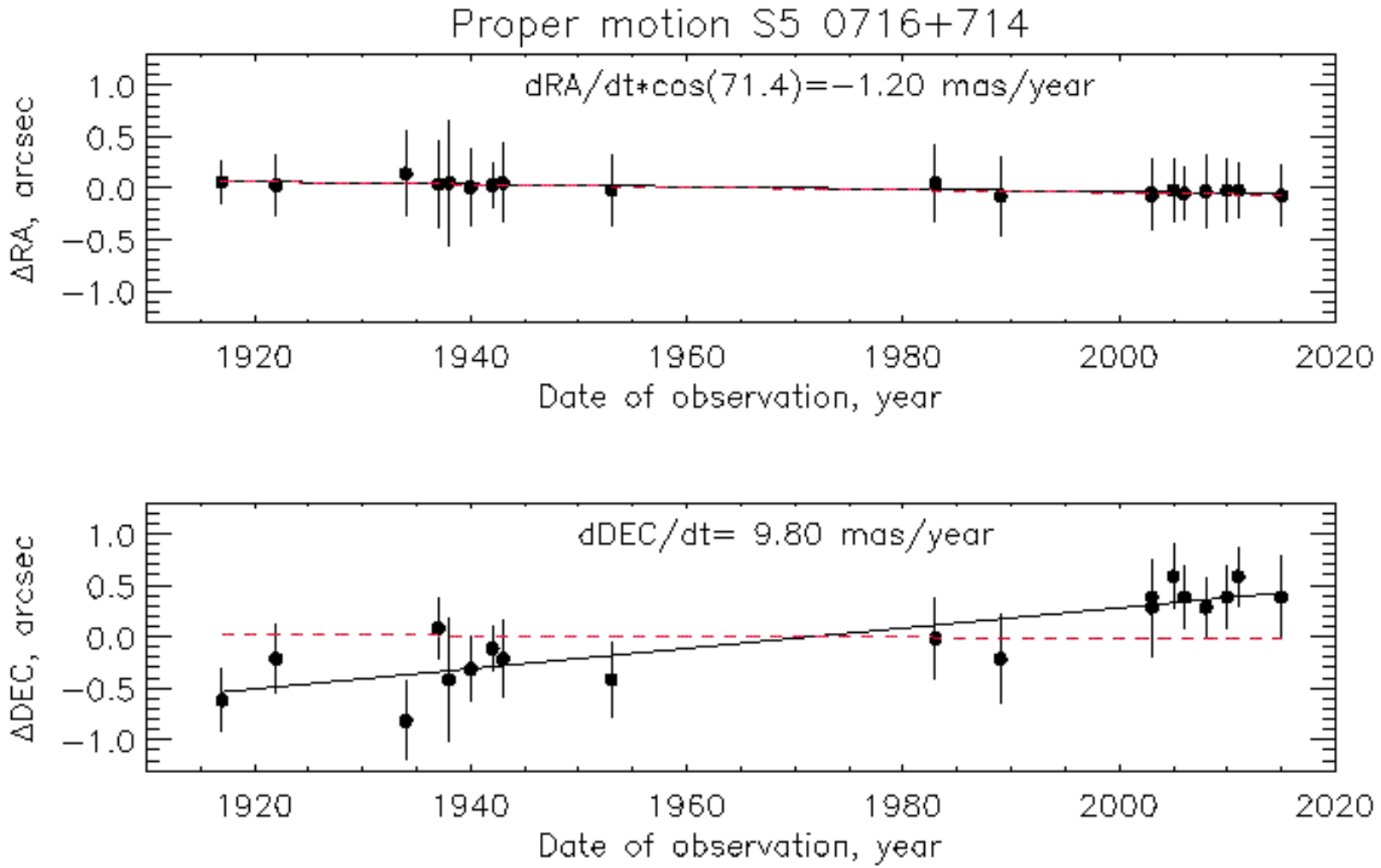
Proper motion S5 0716+714
dRA/dt*cos(71.4)=−1.20 mas/year
ΔRA, arcsec
1.0
0.5
0.0
−0.5
−1.0
1920
1940
1960
1980
2000
2020
Date of observation, year
dDEC/dt= 9.80 mas/year
ΔDEC, arcsec
1.0
0.5
0.0
−0.5
−1.0
1920
1940
1960
1980
2000
2020
Date of observation, year