Optical polarization vector IDV in BL Lac objects – a key to the jet structure

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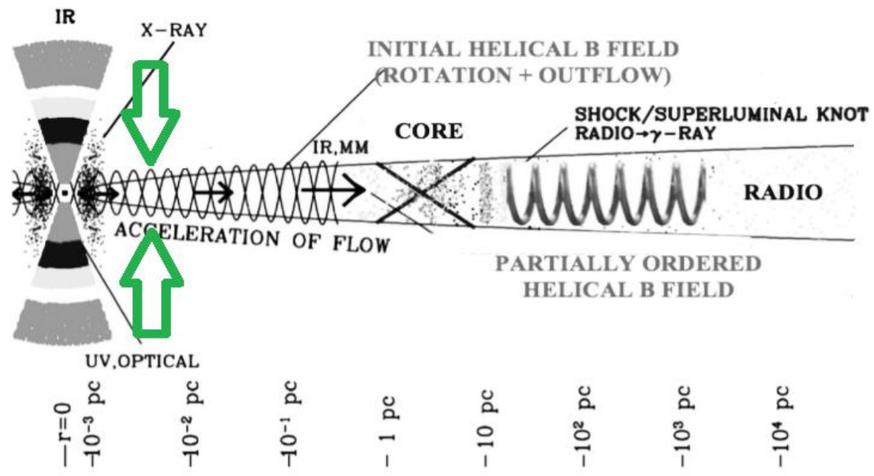
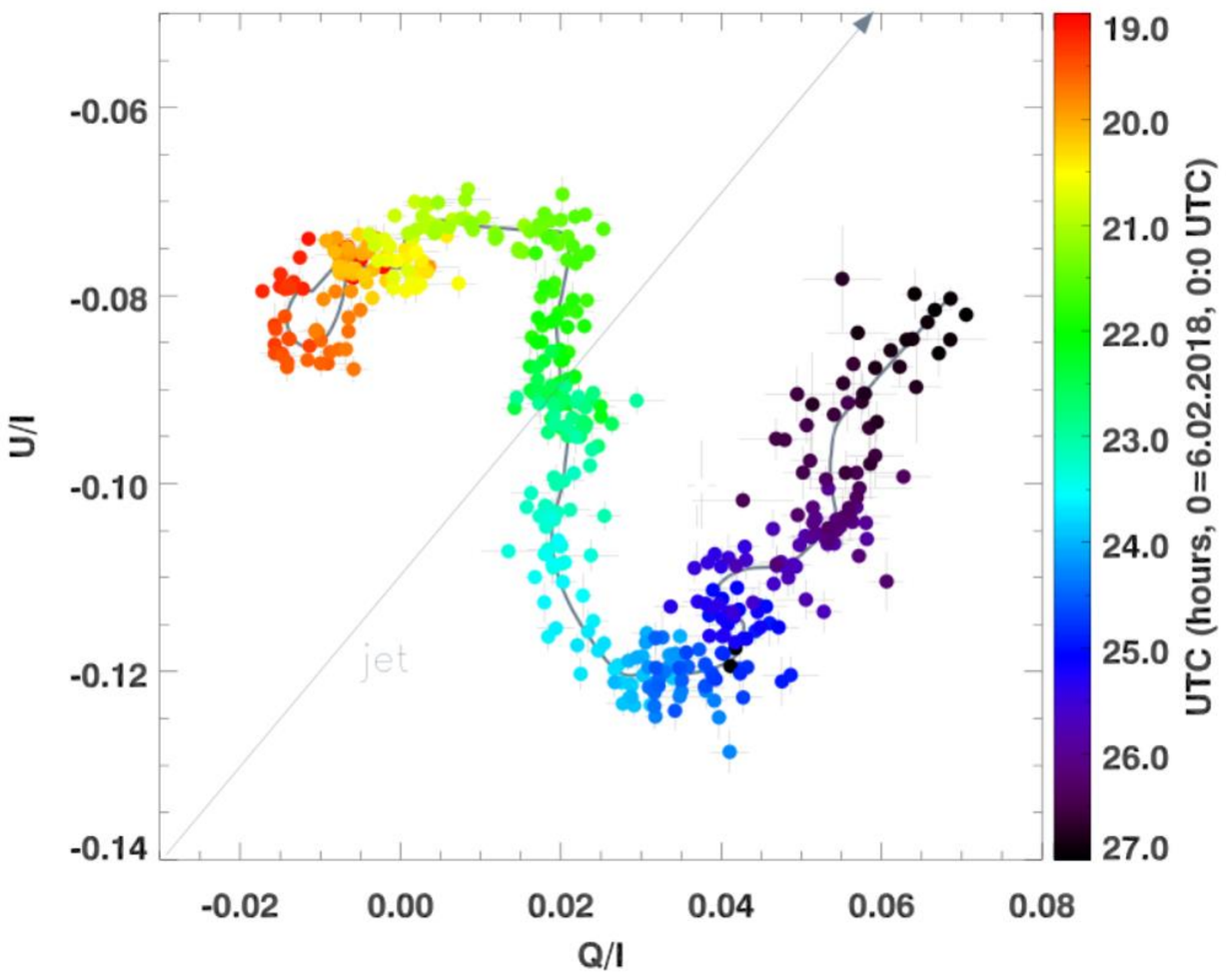
In the course of a number of modern blazar monitoring programs, it has become clear that the polarization vector rotates, and an increase of temporal resolution of observations is necessary to track EVPA rotations at different time scales (Kiehlmann+17,MNRAS).

According to the general model, the optical radiation of blazar having synchrotron origin is produced in unresolved region of the jet at the distance < 0.01 pc from the center (Fig. 1). Therefore, **the variations of brightness and polarization vector direction is a pointer of the plasma motion on scales not resolved in optical band with modern techniques**.

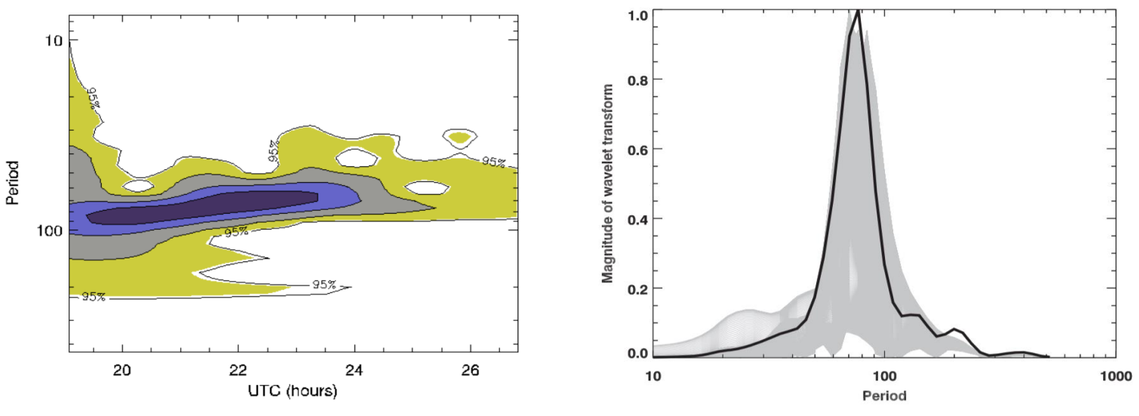


The jet model (Marscher+08,Nature)

In February 2018, 8-hour polarimetric monitoring of **S5 0716+714** with 70-second temporary resolution was conducted with the **6m BTA+SCORPIO-2**. Using the double Wollaston prism and the differential polarimetry technique we minimize the influence of atmospheric depolarization. The polarimetric accuracy is 0.1% and photometric accuracy is 0.005 mag.

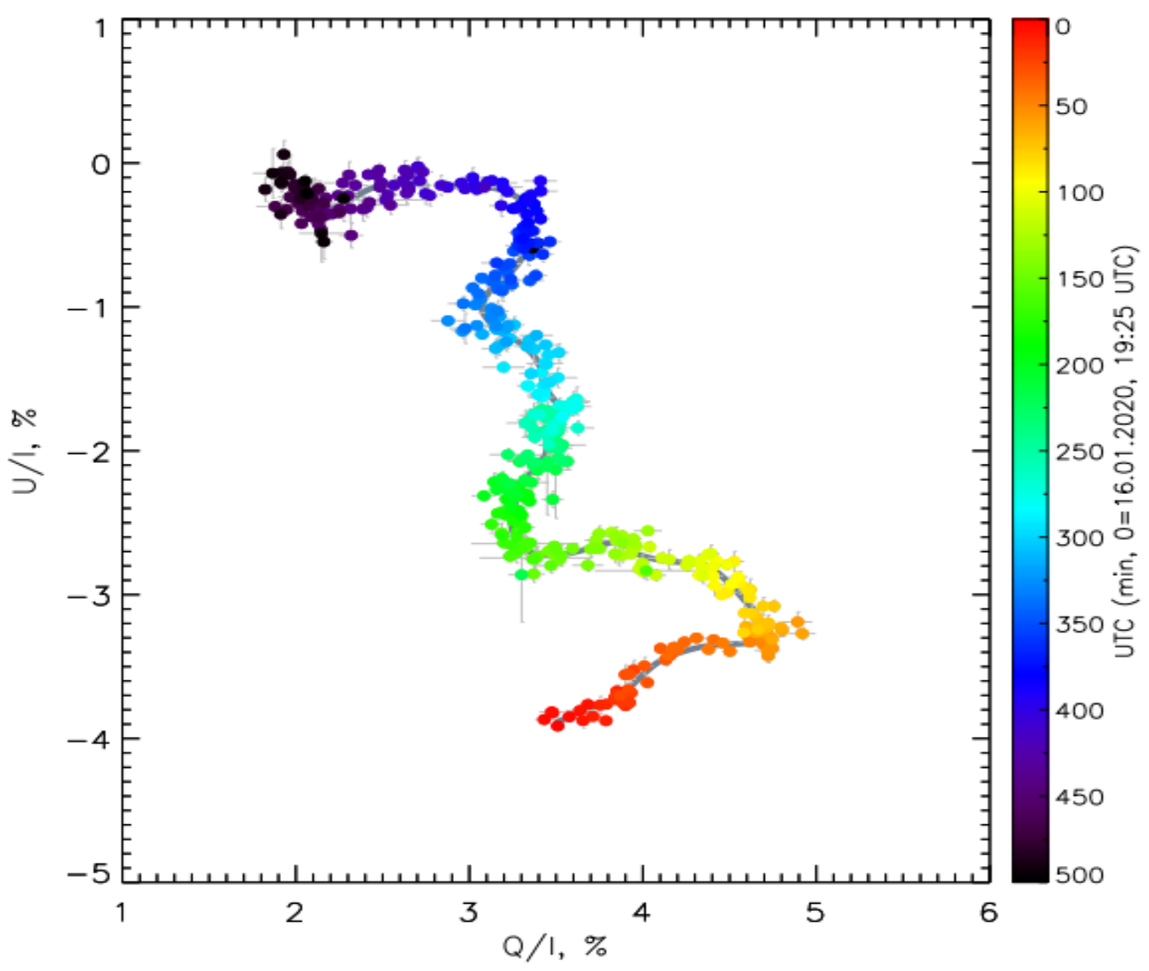


The variations of the normalized Stokes parameters Q and U during the night on the QU-diagram – 2018.

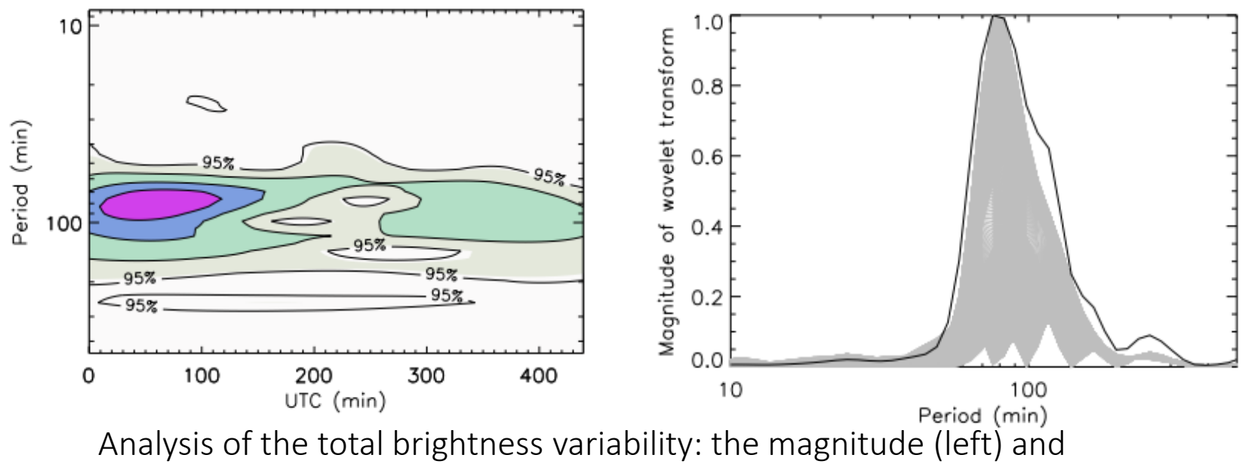


Analysis of the total brightness variability: the magnitude (left) and profiles (right) of the wavelet transformation. The period = 77±10 min.

We repeated the same 8-hour polarimetric monitoring of **S5 0716+714** with 70-second temporary resolution with the **1m Zeiss-1000+StoP** in January, 2020. Using the double Wollaston prism and the differential polarimetry technique we minimize the influence of atmospheric depolarization. The polarimetric accuracy is 0.05% and photometric accuracy is 0.005 mag.

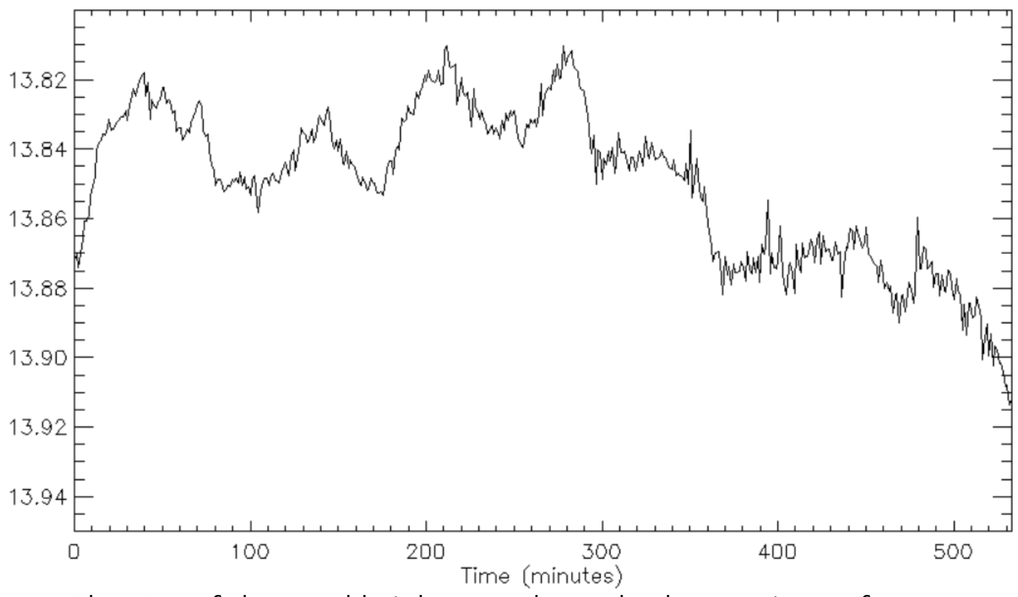


The variations of the normalized Stokes parameters Q and U during the night on the QU-diagram – 2020.



Analysis of the total brightness variability: the magnitude (left) and profiles (right) of the wavelet transformation. The period = 76±10 min.

The variations of brightness and the direction of the polarization vector on the QU-plane have the same period. This can be explained **by the motion of the plasma in the helical magnetic field of the jet**; the brightness changes due to the different observed Doppler boosting (Butuzova+20,APh).

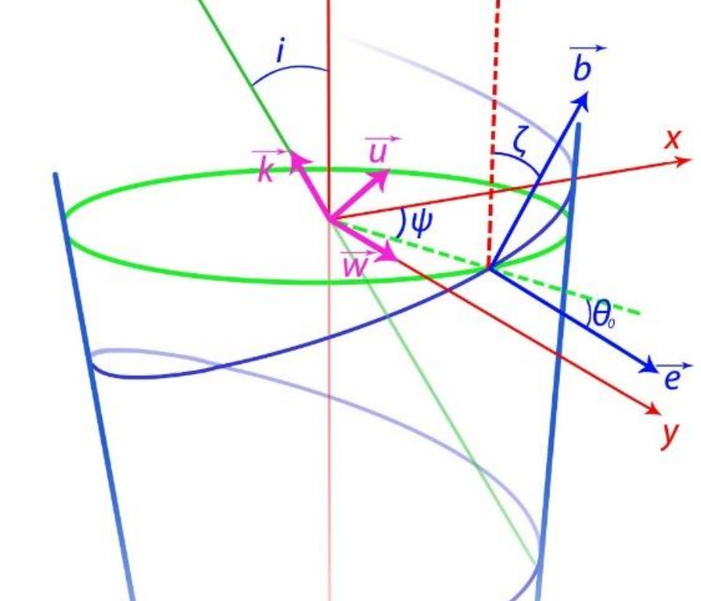


The IDV of the total brightness through observations of S5 0716+714 in 2018.

We considered a model of jet polarization variation due to geometric effects of the plasma motion in a helical magnetic field + the addition of precession of the magnetic field. Approximating our data by this model indicated a precession period of ~ 15 days.

The geometrical model of the plasma motion inside the jet.

- 9-hour polarimetric monitoring revealed the intraday variability on the time-scale **~ 1.5 hour**. QU-plane discovered the pattern of polarization vector changes – ”arches” and ”loops”;
- the linear size of the emitting region - 1.5 light hour or **10 a.u. at the <0.01 pc** distance from the central black hole;
- suggested model of polarization produced by geometrical effects due to relativistic plasma motion in **precessing helical magnetic field** fits the observational data with precession period **~ 15 days**.
- The size of the emitting region **is stable within years**.



Results of numerical simulation of polarization in jet – approximation of observational data.

Shablovinskaya & Afanasiev *The intraday variations of the polarization vector direction in radio source S5 0716+714*, 2019, MNRAS, 10.1093/mnras/sty2943
Afanasiev, Shablovinskaya, Uklein, Malygin *Stokes-Polarimeter for 1-meter telescope*, 2021, Astr.Bull ., 10.1134/S1990341321010028