Inhomogeneous jet, from LLAGN M81* to Blazar B0954+658

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Inner jet of BL Lac

Multi-frequency behavior of CTA 102

Optical R-band light curves

230 GHz

37 GHz

Doppler factor

View angle

R-band flux corrected with beaming effect

Inhomogeneous jet model (for Blazar)

Emission at different frequencies comes from different regions along a continuous jet (jet is inhomogeneous). Blazar SED variability can be explained by a twisted inhomogeneous jet.

Multi-wavelength behavior of B0954+658

Gamma ray

X ray

Optical

Optical polarization

P. A. of optical polarization

Another example of the inhomogeneous jet model.
Jet components in CTA 102

Jet components in B0954+658

In the case of B0954+658, the extended emission falls off sharply with increasing frequency.
1. Bent jet
2. View angle at high frequency is smaller.
In the case of LLAGN, M81* we found...
Position angle changes

- PA of jet is frequency dependent.
- The PA-Frequency relation was shifted in parallel vs. time.

Position angle with respect to frequency.

CVN 2014, KaVA 2015, VLBA 2016
Core-shift

Core-shift (43.9-87.8GHz)
57 ± 14 μas @ -151°

SFPR image of M81*

SFPR Source-frequency Phase-referencing

Jiang et al. ApJL, 2018
Images of M81*

Image of M81* at 3.4 mm. 0.1 mas ~ 0.0016 pc ~ 300 Rsch

Spectral index map of M81* (43-87 GHz).

Peak=45.3 mJy/beam
RMS=0.34 mJy/beam
Dynamic range ~ 130

Jiang et al. ApJL, 2018
Core size of M81*

Core size vs. freq, $s \propto \lambda^{0.88}$

Jiang et al. ApJL, 2018
Discrete jet

Discrete knot ejection from the jet after low energy X-ray flare in 2011.

Radio flare spectral energy distribution. High-resolution radio knot motion (~0.5 c).

Precession of jet

The position angle observed at 5GHz showed a precession period of \(~7\) yr and a speed of drifting \(~0.5\) deg/yr.

Summary

- In the case of LLAGN, M81* shows similar phenomenon as that of blazar sources.
- Inhomogeneous jet model could be used to explain observational results of M81*.
- Jet precession/wobbling may be due to Lense-Thirring effect or Kelvin-Helmholtz instability.
Thank you!