Activity cycles of blazars and quasars from the VLBI observations

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Fulfilled projects

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Outline

1. What are the activity cycles?

2. Activity cycle of the blazar S5 1803+784

3. How the cycle evolves with time

4. AGN with periodical light curves and periodical optically thick flares

Summary
1. Introduction

Active galactic nuclei

Wehrle et al
Variability of Active Galactic Nuclei is very complicated – many complex
Evolution of a primary perturbation in the base of the jet

Gomez (1997)

+ Jet component(s) ejection

Marscher (1992)
Activity cycle = Time between two flares with VLBI Component(s) ejections, large time delays, spectral evolution.
- How the jet structure evolution is connected with outbursts?
- Which flares are coming from the core and which from the jet?
- How long are the activity cycles of AGN? Does it change with time?

**Activity cycles**

**Observations**

- Calculated spectra, time lags, analyzed VLBI data, compared the total flux-density variability with the jet structure evolution.

43 GHz VLBI Monitoring + archival data

UMRAO Monitoring 4.8, 8, 14.5 GHz + archival data

Metsahovi Monitoring 22, 37 GHz + archival data

Aller et al. 1985
Terasranta et al. 1995
Jorstad et al. 2001, 2002
-- Analysed light curves and VLBI structure changes for 21 sources
-- 15 quasars, 4 blazars and 1 radio galaxy
-- Activity cycles are

0059+581, 0133+476, 0202+149, 0316+413 (3C 84),
0458-020, 0528+134, 0735+178, 0923+392 (4C 39.25),
0945+408, 1308+326, 1510-089, 1641+399 (3C 345),
1730-130, 1739+522, 1741-038, 1803+784, 2145+067,
2223-052 (3C 446), 2230+114 (CTA 102), 2251+158
(3C 454.3)
94 VLBI epochs at 1.6 GHz, 2.3 GHz, 5 GHz, 8 GHz, 15 GHz, 22 GHz


Activity cycles
Seven jet components which remain stationary over 25 years. Only one flare, last broad outburst C shows large opacity and time delays.

→

Activity cycle of S5 1803+784 is more than 25 years.
Activity cycles

How an activity cycle evolve with time

- Time delays, spectra, amplitude and width of the flares changing gradually and accompanied with the jet component ejections after the maximum for 2145+067, 3C 446 (2223-052), 3C 454.3, 0133+476
- These outburst is an evolution of one perturbation in the base of
• For four sources we found that activity cycles coincides with periodicity in the total flux-density variability and VLBI structure changes.

• Something causes periodical perturbations of the base of the jet.

• Binary black holes? Accretion disc instabilities?
Main results:

• Applied a new method of calculating activity cycles from total flux-density analysis and VLBI structure changes
• Calculated activity cycles of 21 blazars and quasars
• Activity cycles are long – are in average 4-8 years in source frame
• Can last for more than 25 years with one jet component ejection per 25 years
• During the cycle the frequency-dependent time lags, opacity, amplitudes of the flares and widths are changing gradually → jet component(s) are ejected during the maximum opacity which can be explained with the shock-in-jet model

**Fulfilled projects**

1. Outburst/component ejection relation. Activity cycles in blazars and quasars
2. Structure evolution of the blazar S5 1803+784
3. Helical trajectory in 0605-085
4. AGN with periodical light curves
5. Rapid variability of AGN
6. AGN with restarted activity

**Research experience**

**Proposed projects**
1. Outburst/component ejection relation. Activity cycles in blazars and quasars → archives, EVN, VLBA
2. AGN with periodical light curves → WSRT, EVN
3. Rapid variability of AGN → WSRT, Lofar
4. AGN with restarted activity → Lofar
Outline

Outburst/component ejection relation.
Activity cycles in blazars and quasars
Structure evolution of the blazar S5 1803+784: observations vs. theory
Helical trajectory in 0605-085 AGN with periodical light curves
Rapid variability of AGN AGN with restarted activity
Fulfilled projects

1. Outburst/component ejection relation. Activity cycles in blazars and quasars
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