Kinetic- vs Magnetic-driven Blazar Jet Models

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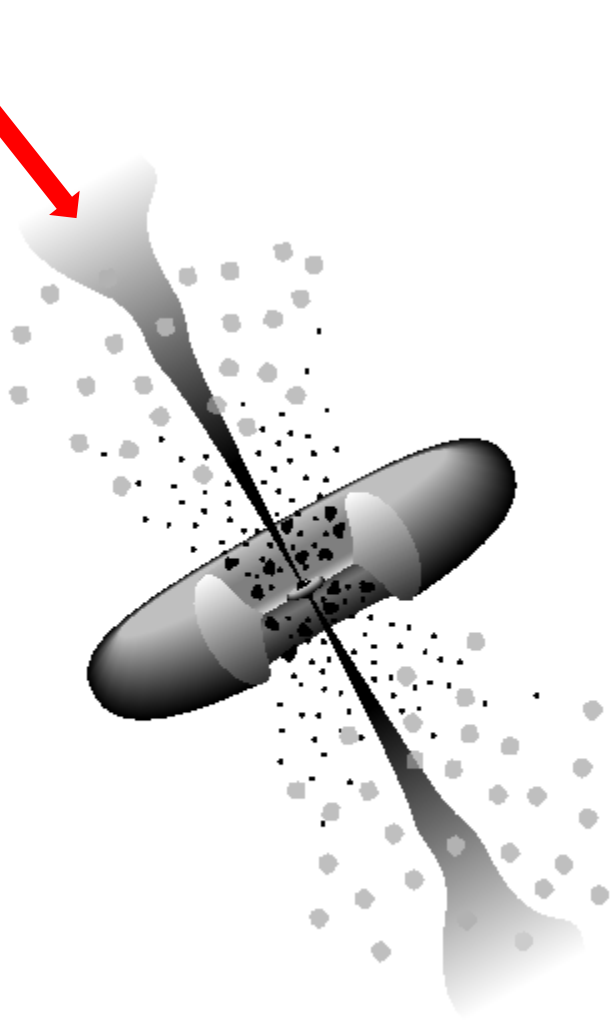
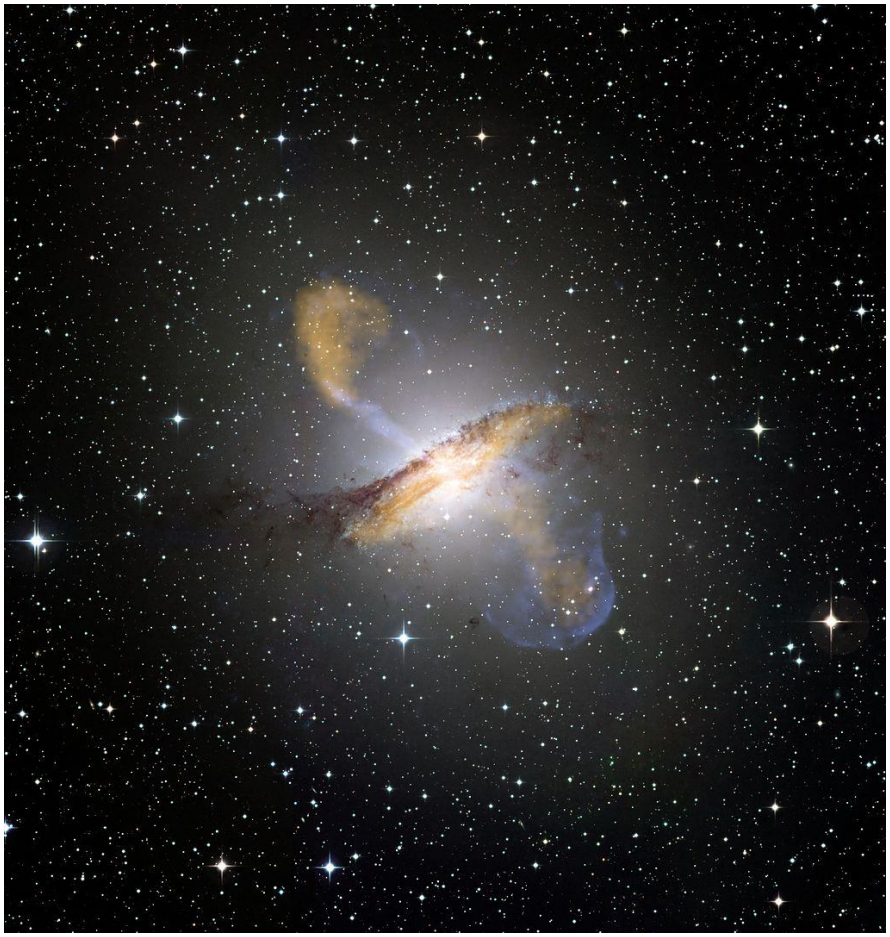
Nov 4, 2016

Active Galactic Nuclei

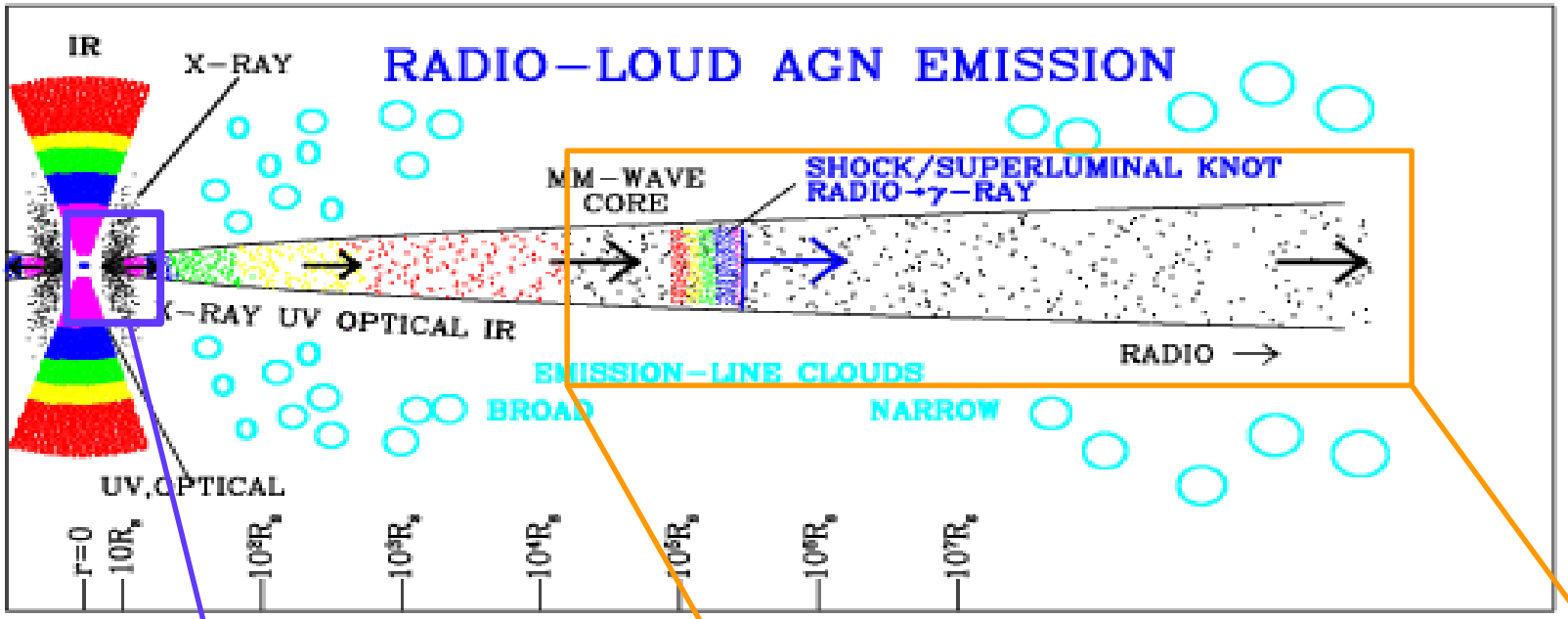
Blazar



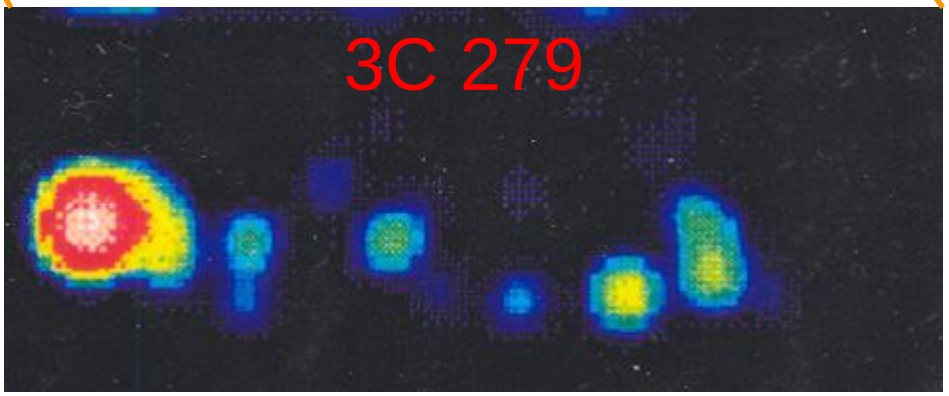
Urry & Padovani, 1995



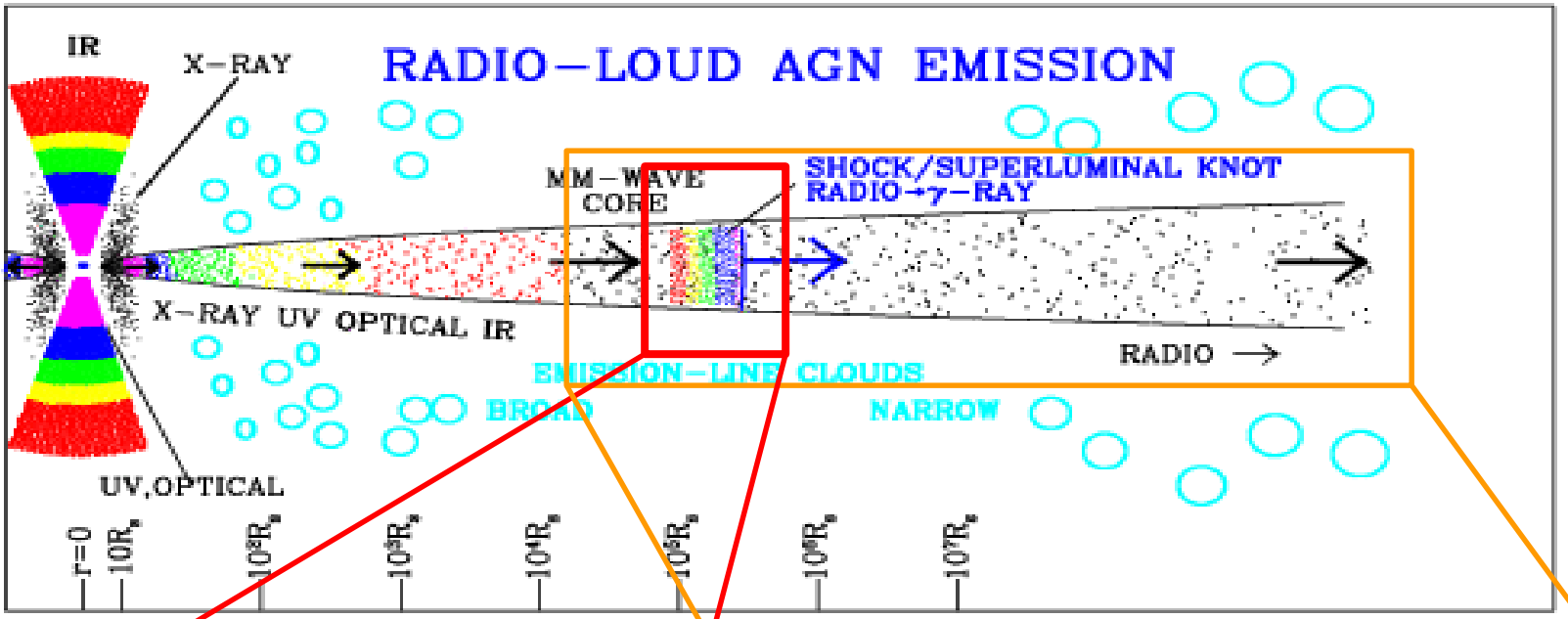
Blazar Jet

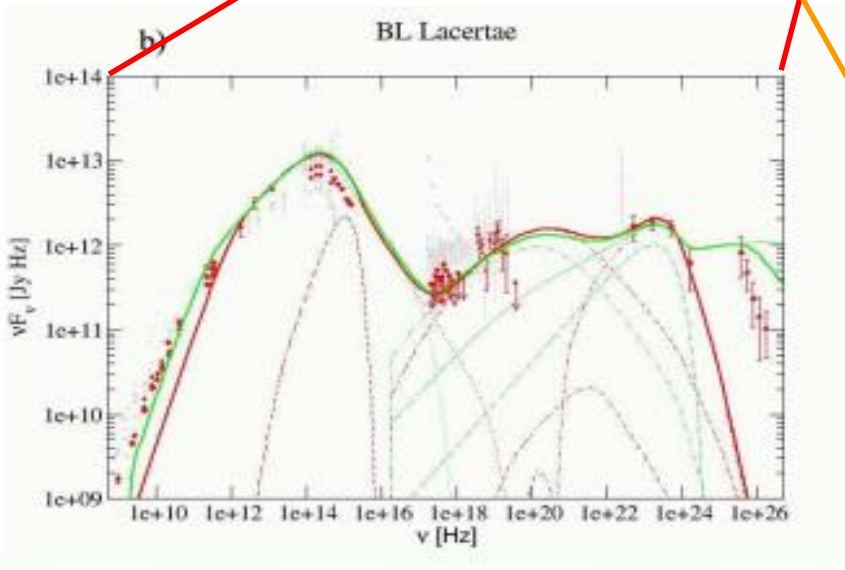


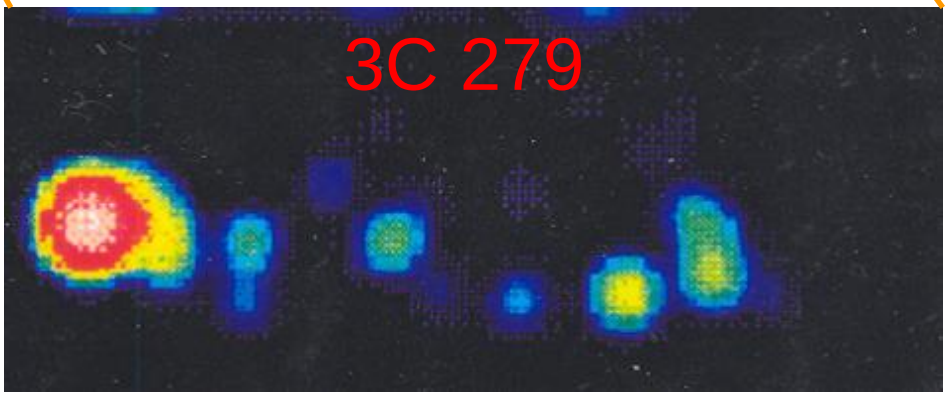
Highly magnetized



Blazar Jet


RADIO–LOUD AGN EMISSION
IR
X–RAY
UV,OPTICAL
X–RAY UV OPTICAL IR
MM–WAVE CORE
SHOCK/SUPERLUMINAL KNOT
RADIO→γ–RAY
RADIO →
EMISSION–LINE CLOUDS
BROAD
NARROW
r=0
10R*
10²R*
10³R*
10⁴R*
10⁵R*
10⁶R*
10⁷R*


b)
BL Lacertae
1e+14
1e+13
1e+12
1e+11
1e+10
1e+09
νF_ν [Jy Hz]
1e+10 1e+12 1e+14 1e+16 1e+18 1e+20 1e+22 1e+24 1e+26
ν [Hz]


3C 279

Jet Models

Two types of jet models:

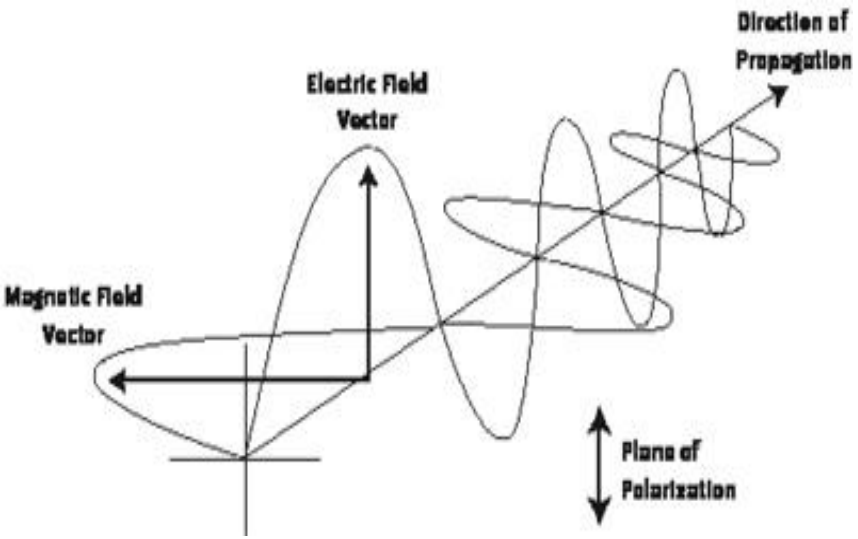
Kinetic-driven: Jet magnetic energy quickly converts into bulk kinetic energy after launch, then forms shocks and accelerate nonthermal particles, which give rise to emission.

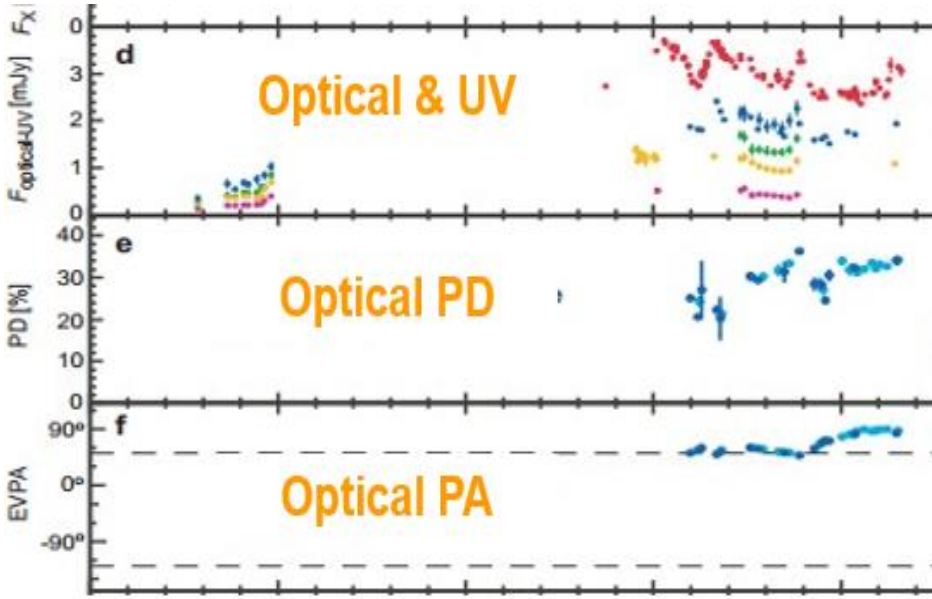
- Evidence: Radio observations see bright moving and standing knots.

Magnetic-driven: Jet keeps high magnetization. Current-driven instability will locally dissipation magnetic energy to accelerate nonthermal particles and create flares.

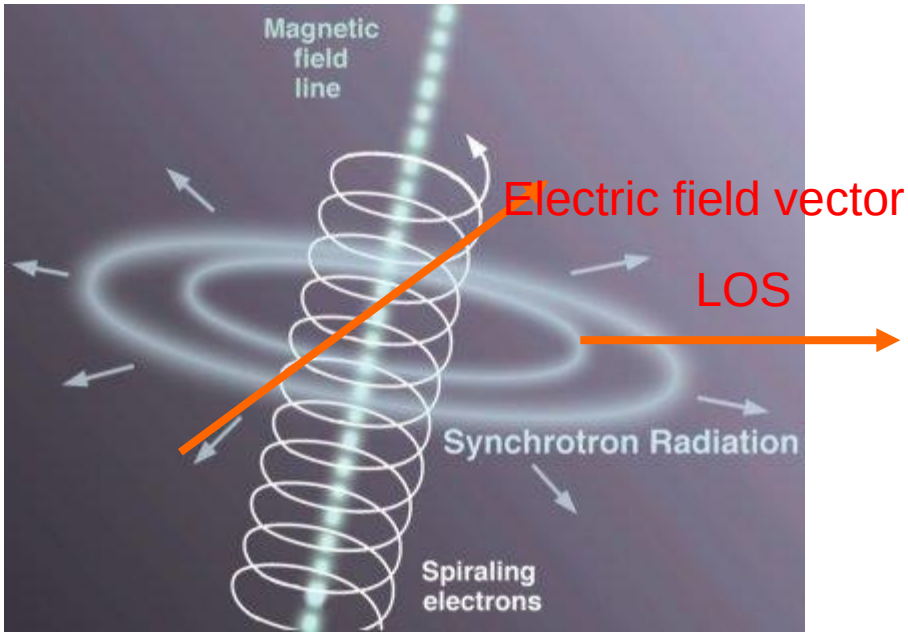
- Evidence: Minute-scale variability, active polarization variations during flares.

Synchrotron and Polarization

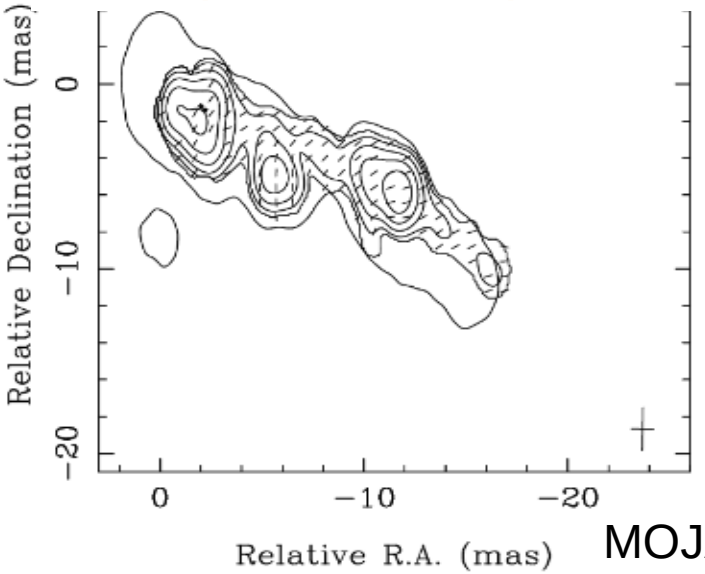




Abdo et al. 2010

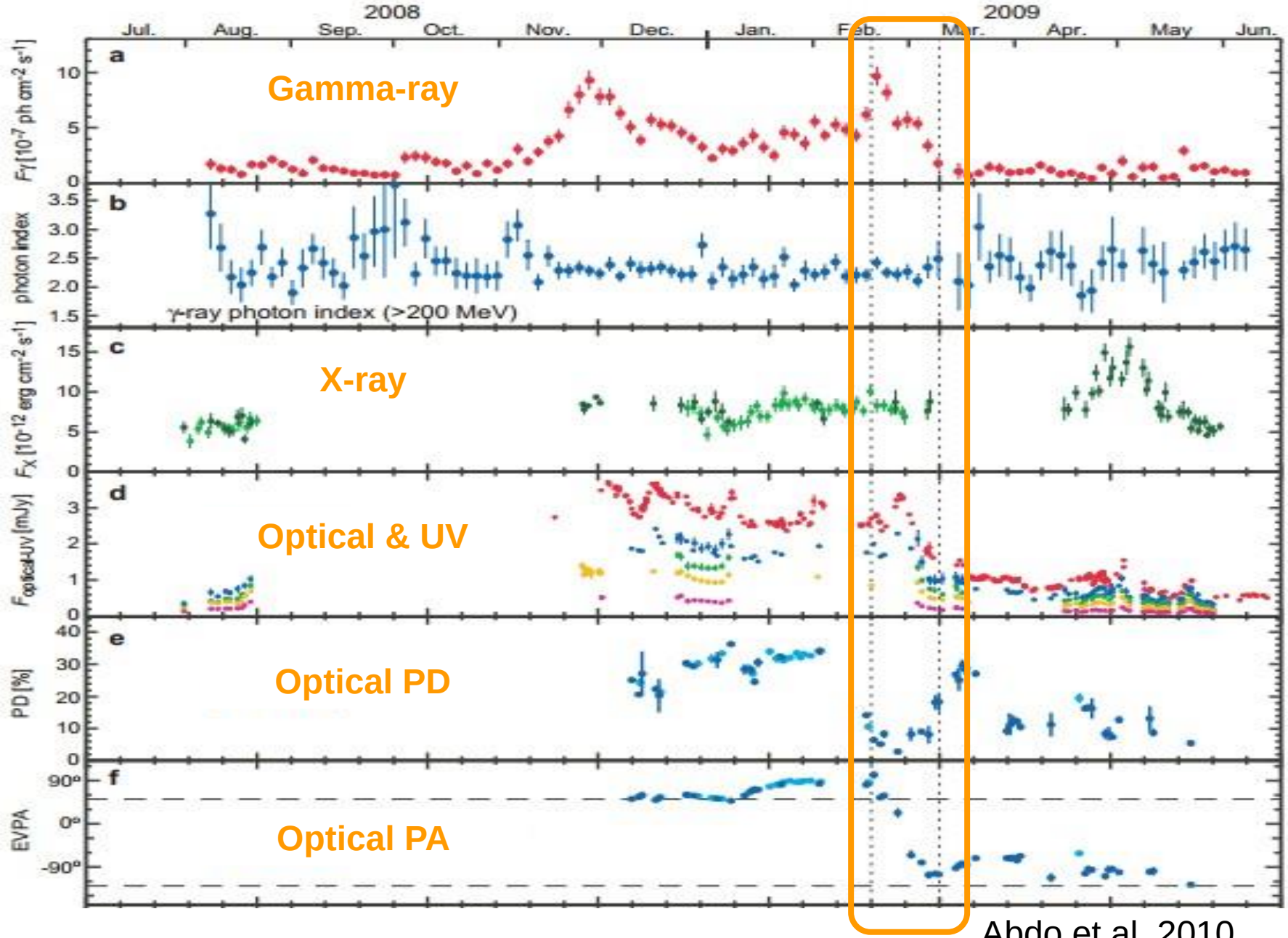


VLBA polarized map of 3C 273



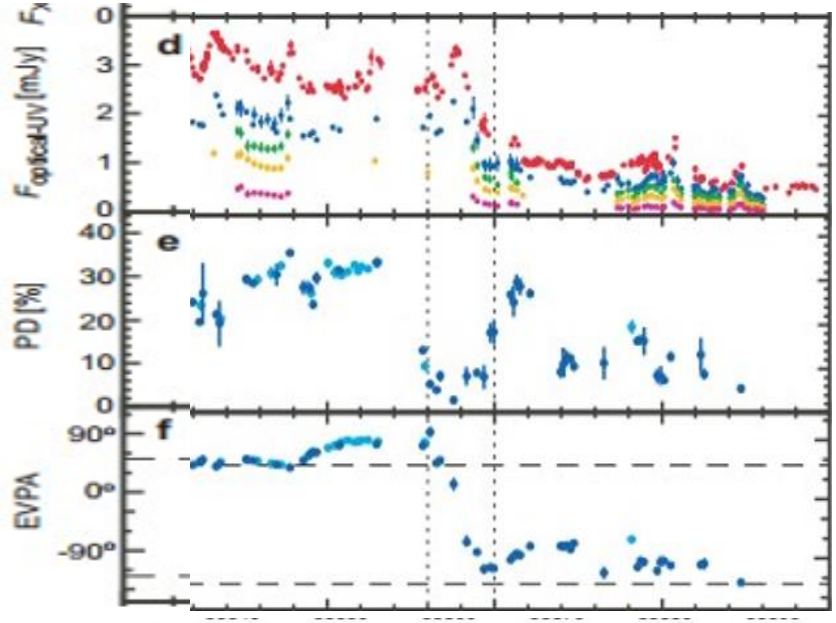
MOJAVE

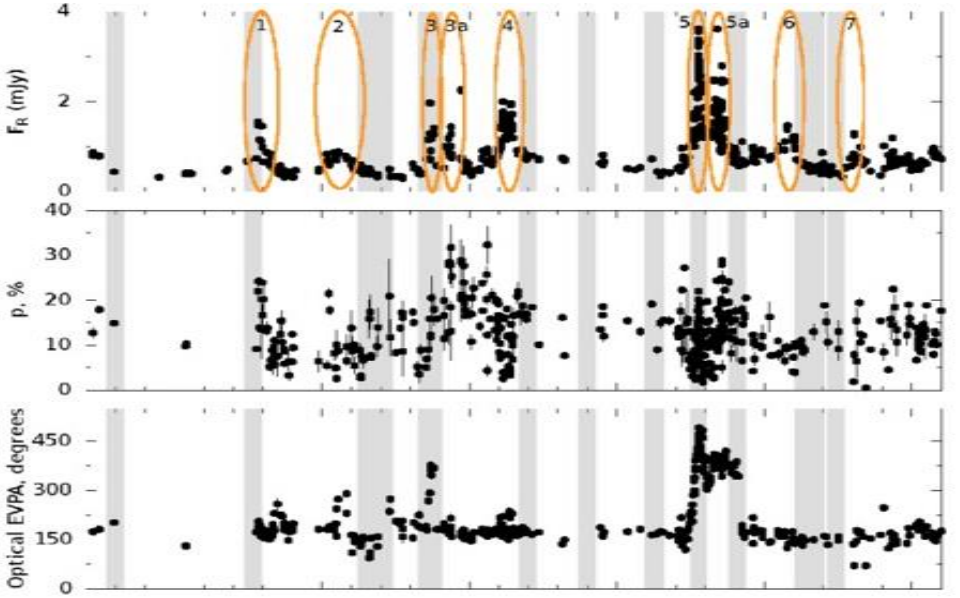
Multi-wavelength Variability and Polarization

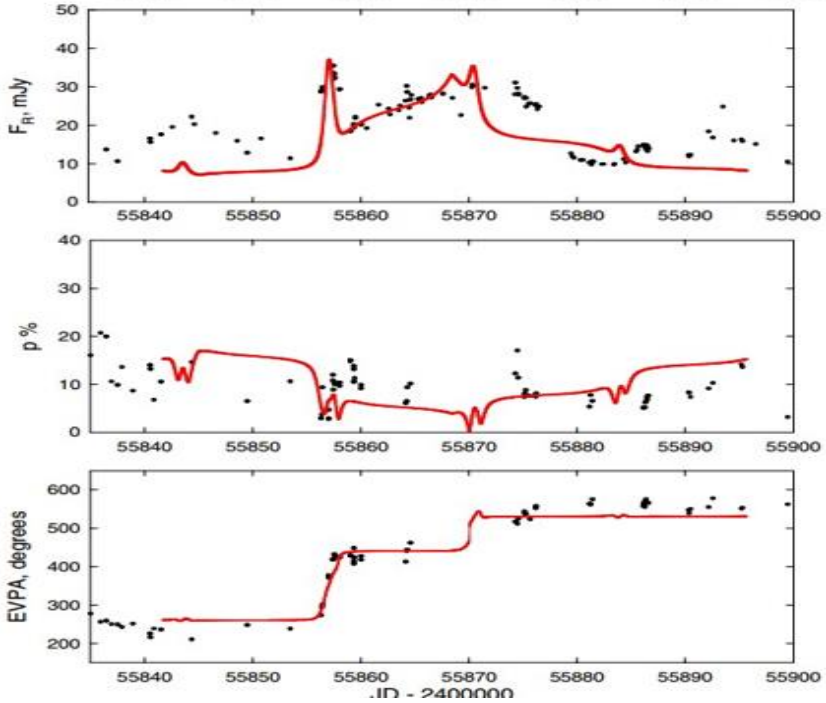


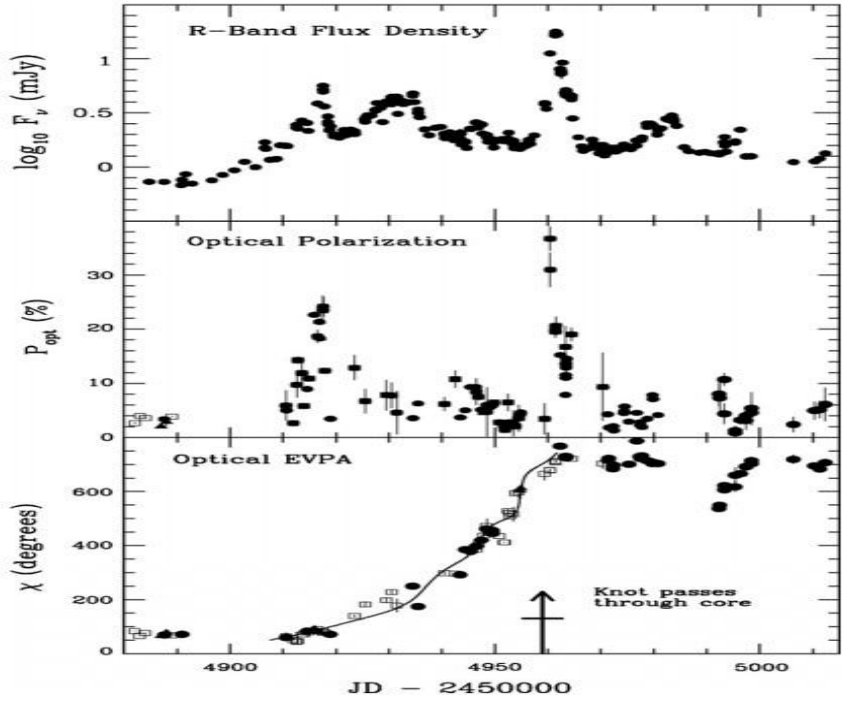
Abdo et al. 2010

Polarization Observations

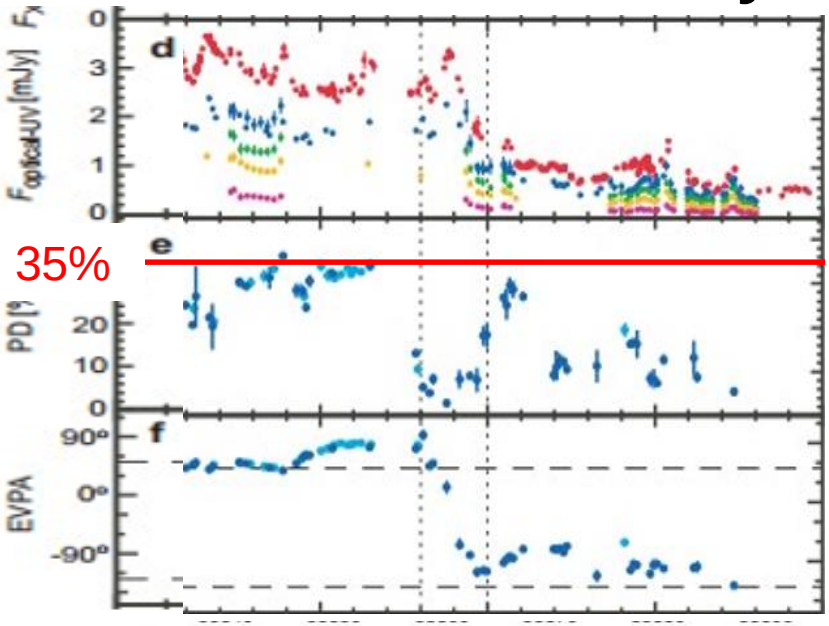


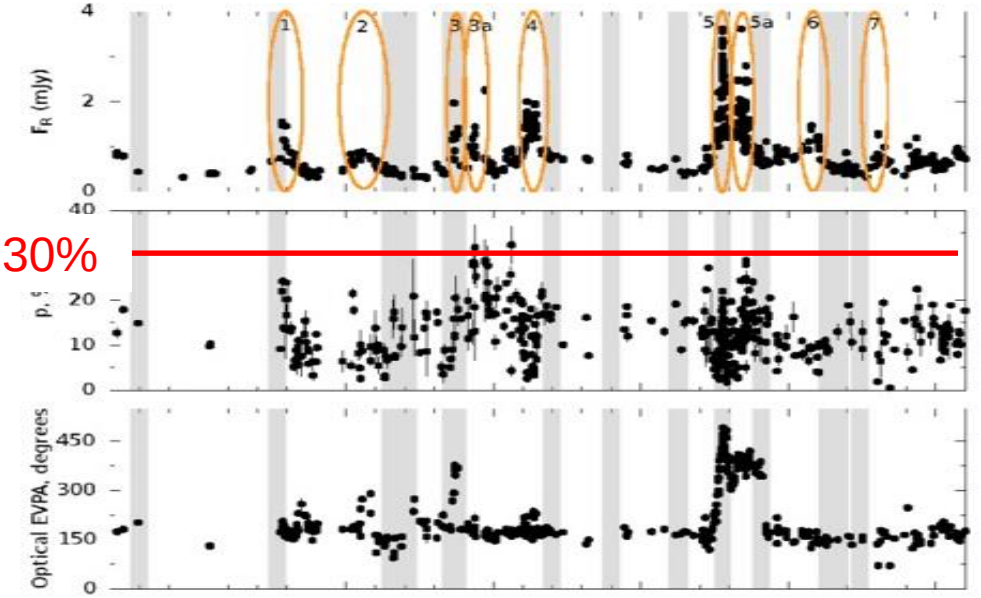


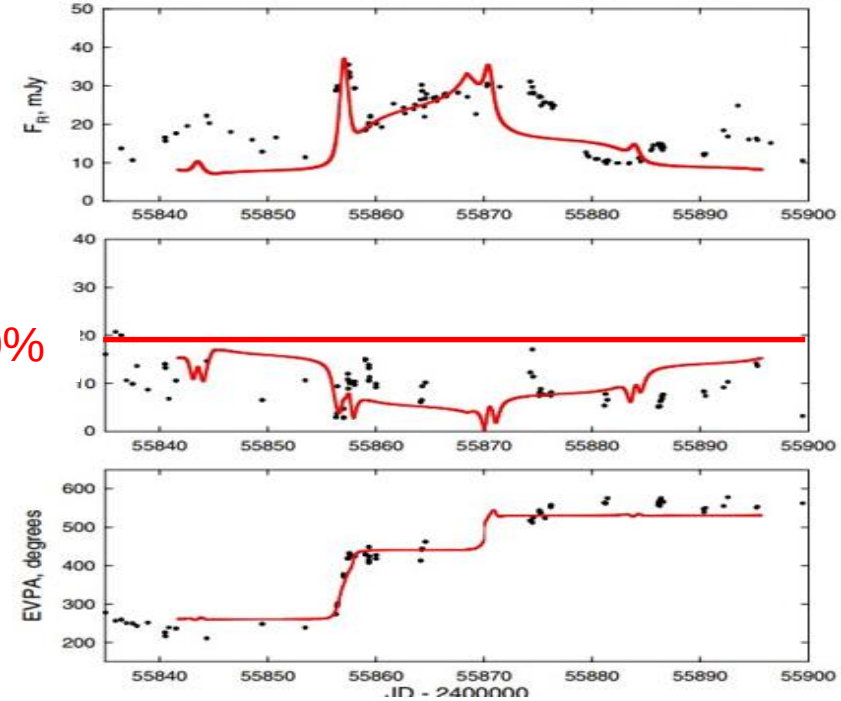


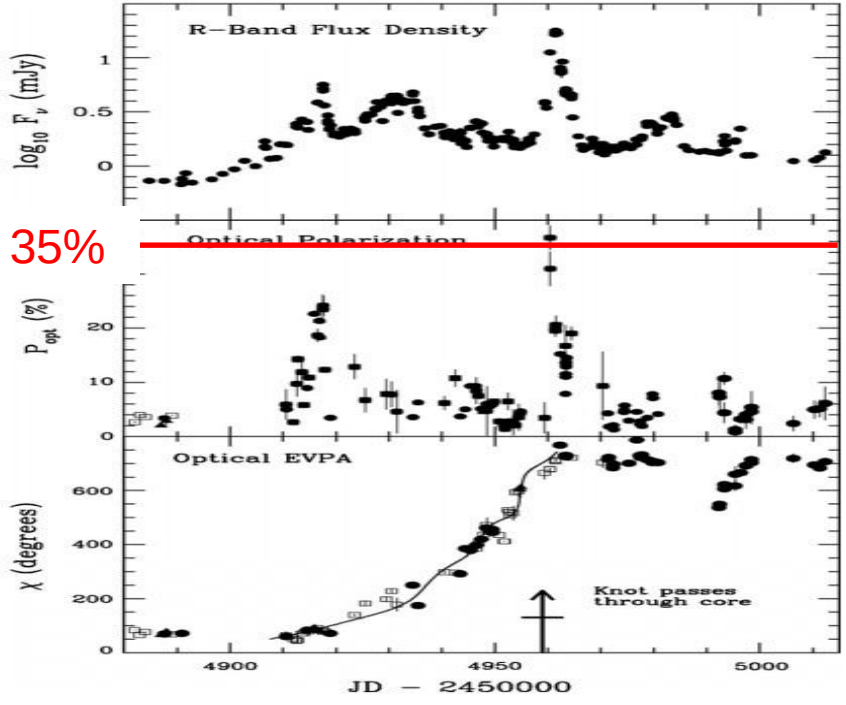


Polarization Stability

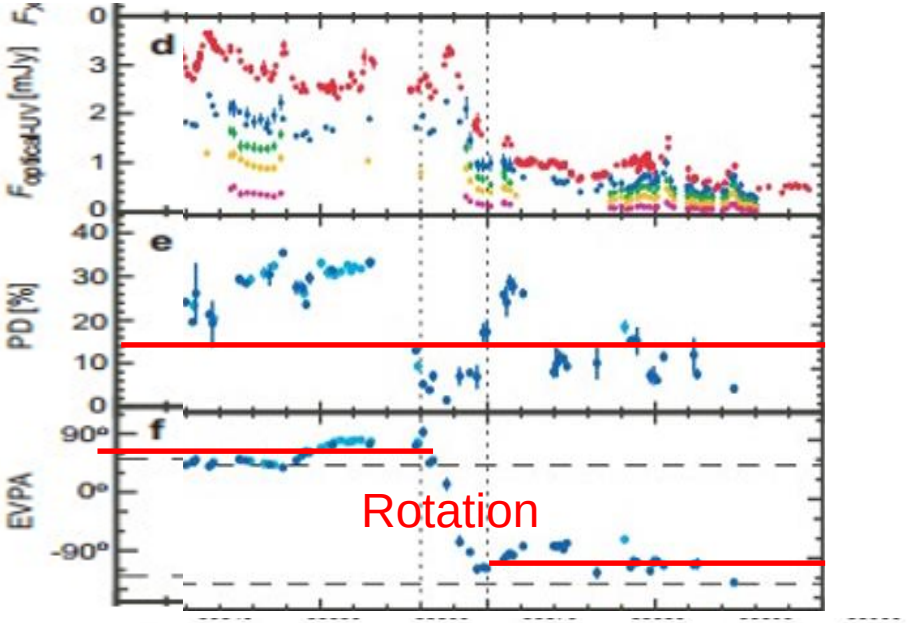


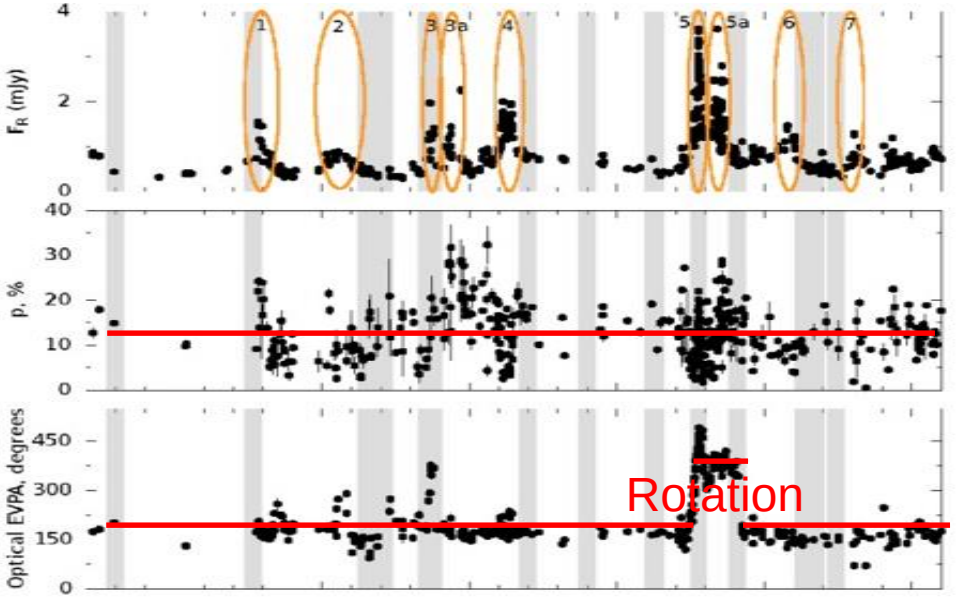


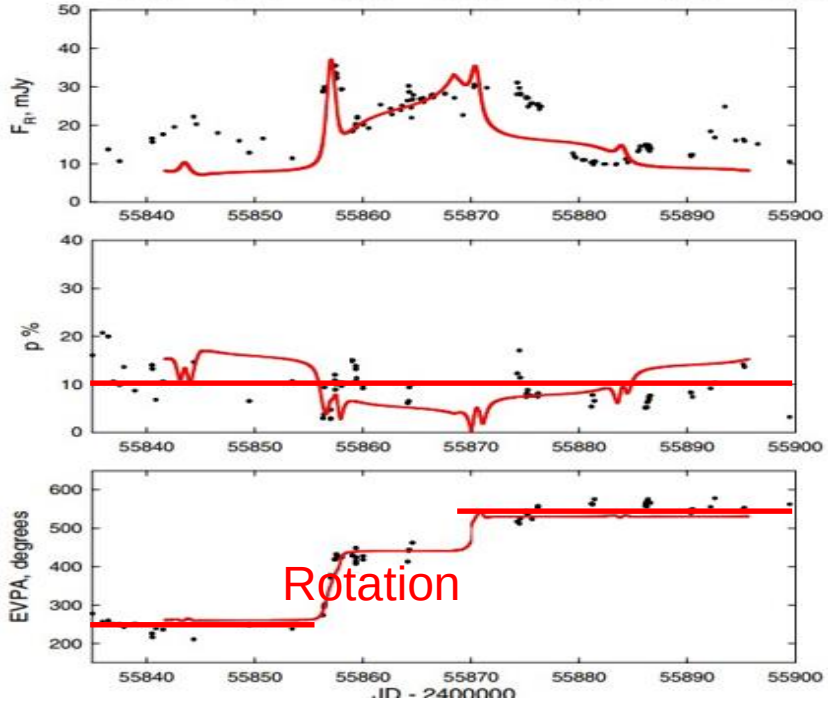


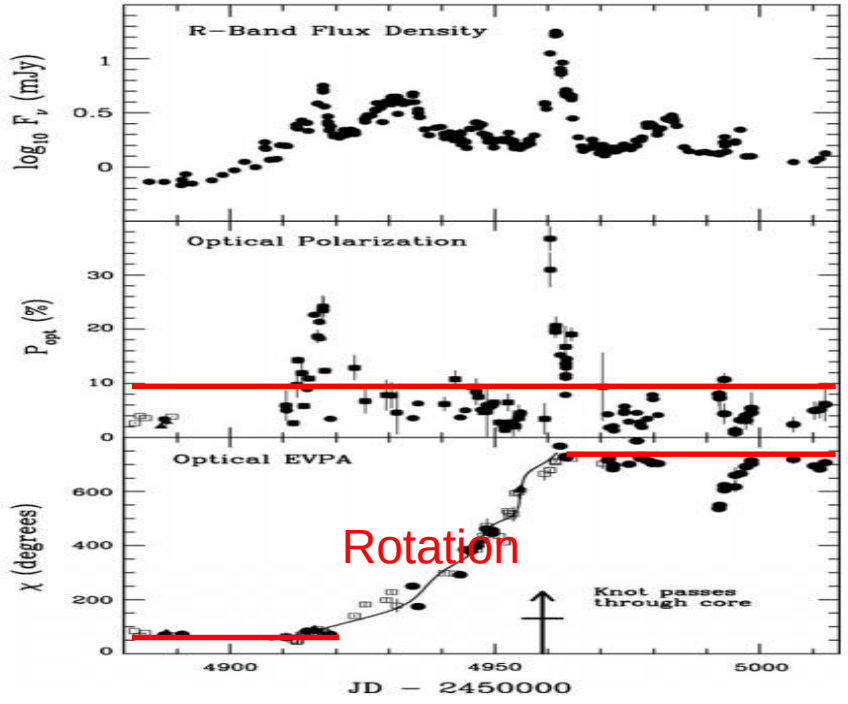


Polarization Restoration

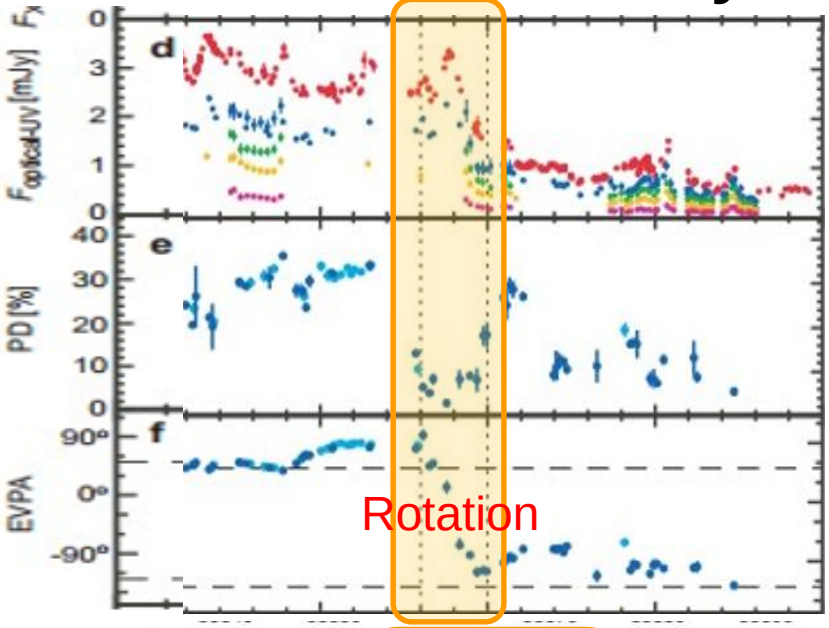


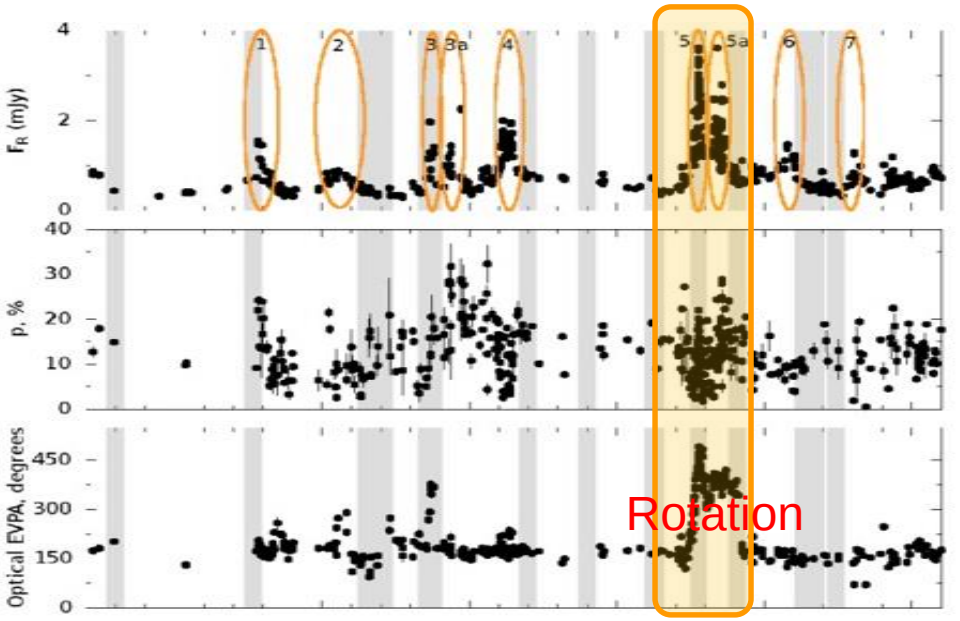


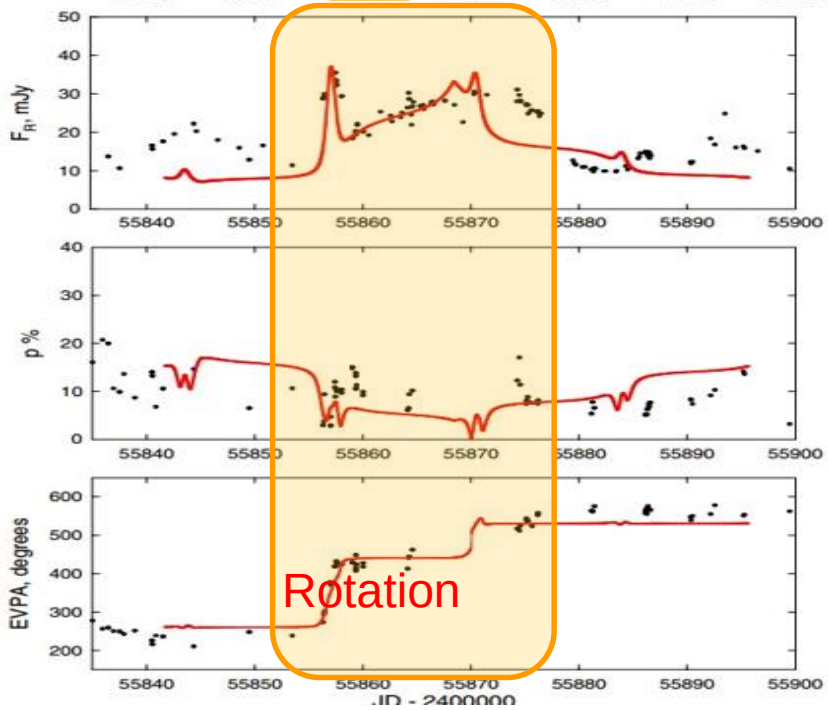


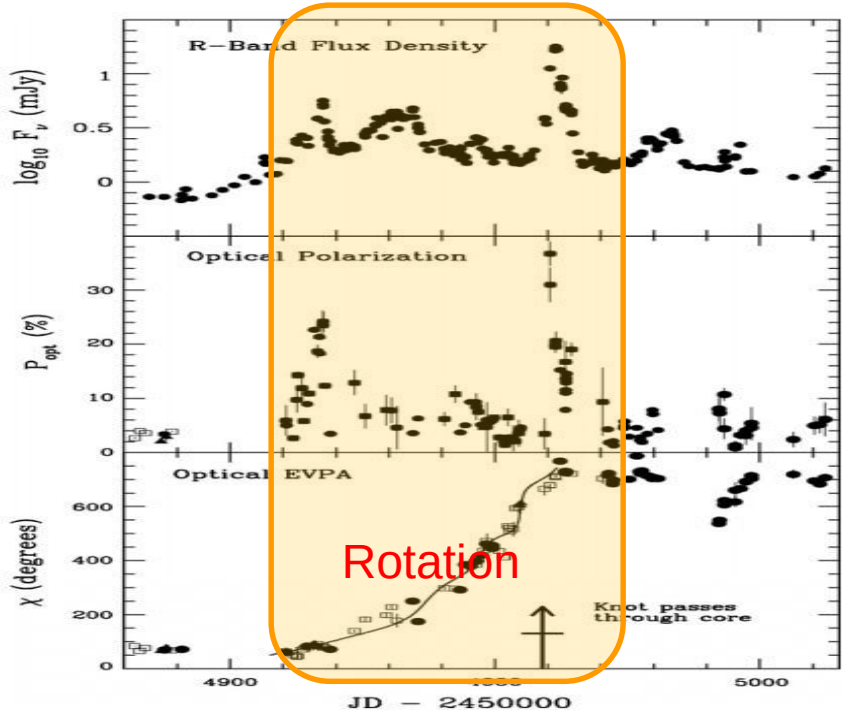


Polarized Variability









Summary of Polarization Observations

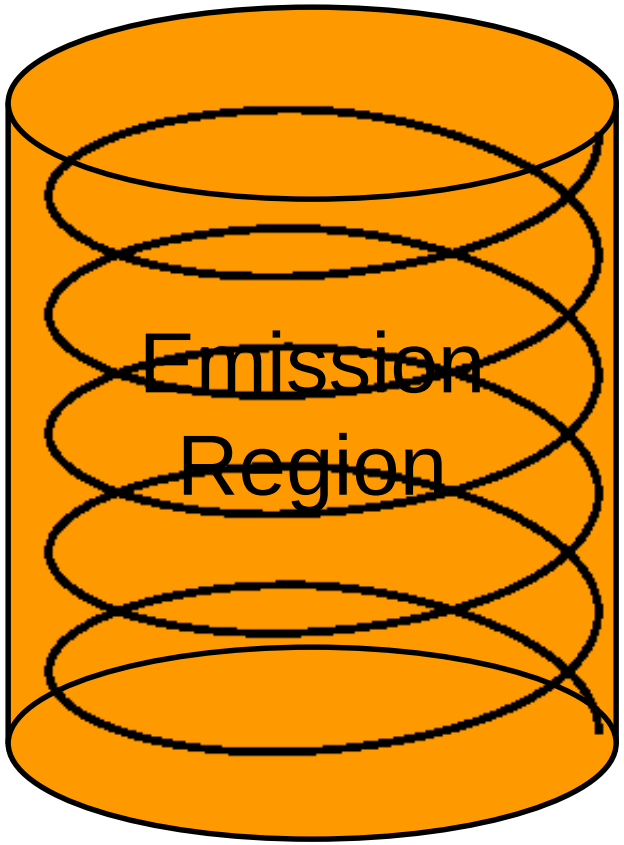
1. Highest polarization degree cannot exceed 40~50%
2. Polarization signatures tend to restore its initial state after major variations
3. Strong polarization signatures tend to accompany strong flares
4. Blazars that have shown major polarization variations tend to show stronger polarization variations than the ones without major polarization changes

In terms of magnetic field evolution:

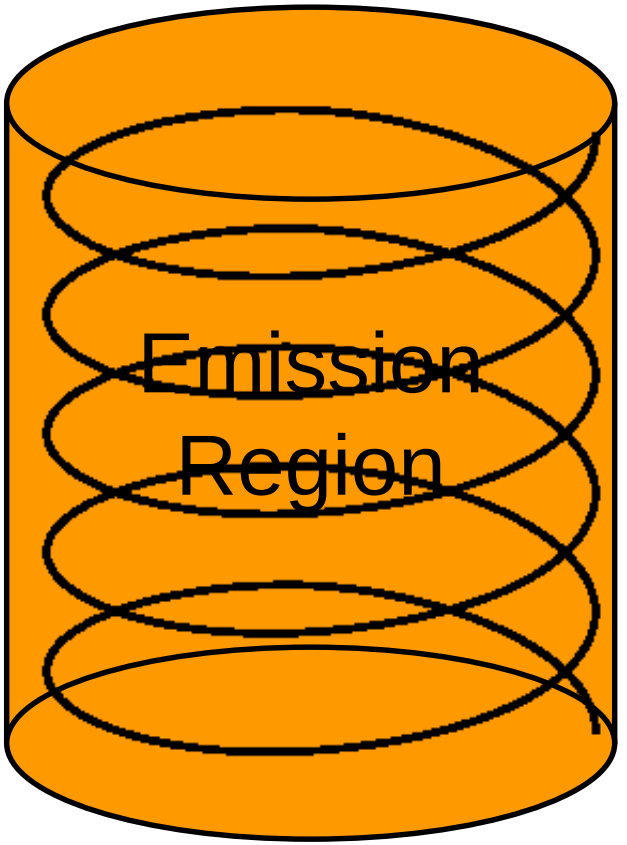
- Magnetic field should be partially ordered even in the strongest flare, and would generally restore its initial state
- Some blazars tend to have more active magnetic field evolution, especially during stronger flares

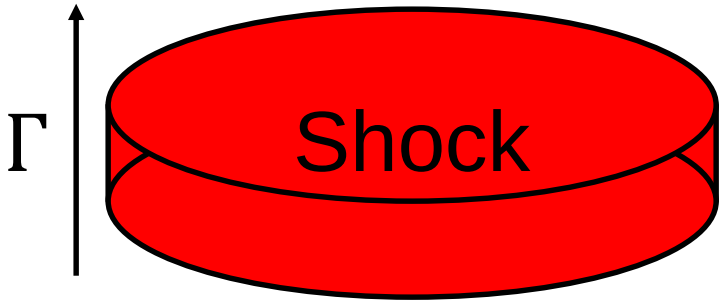
Shock vs Kink

Shock

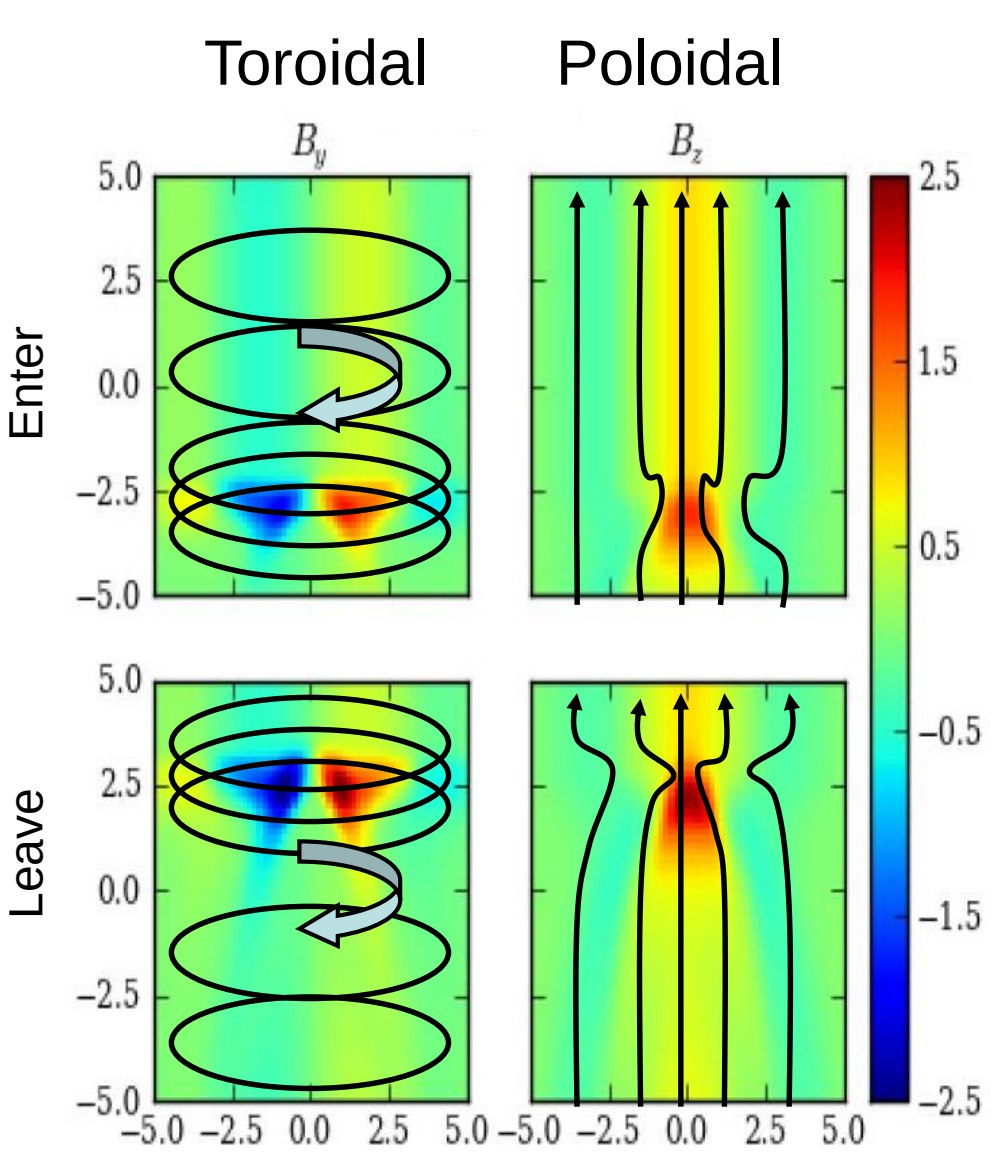


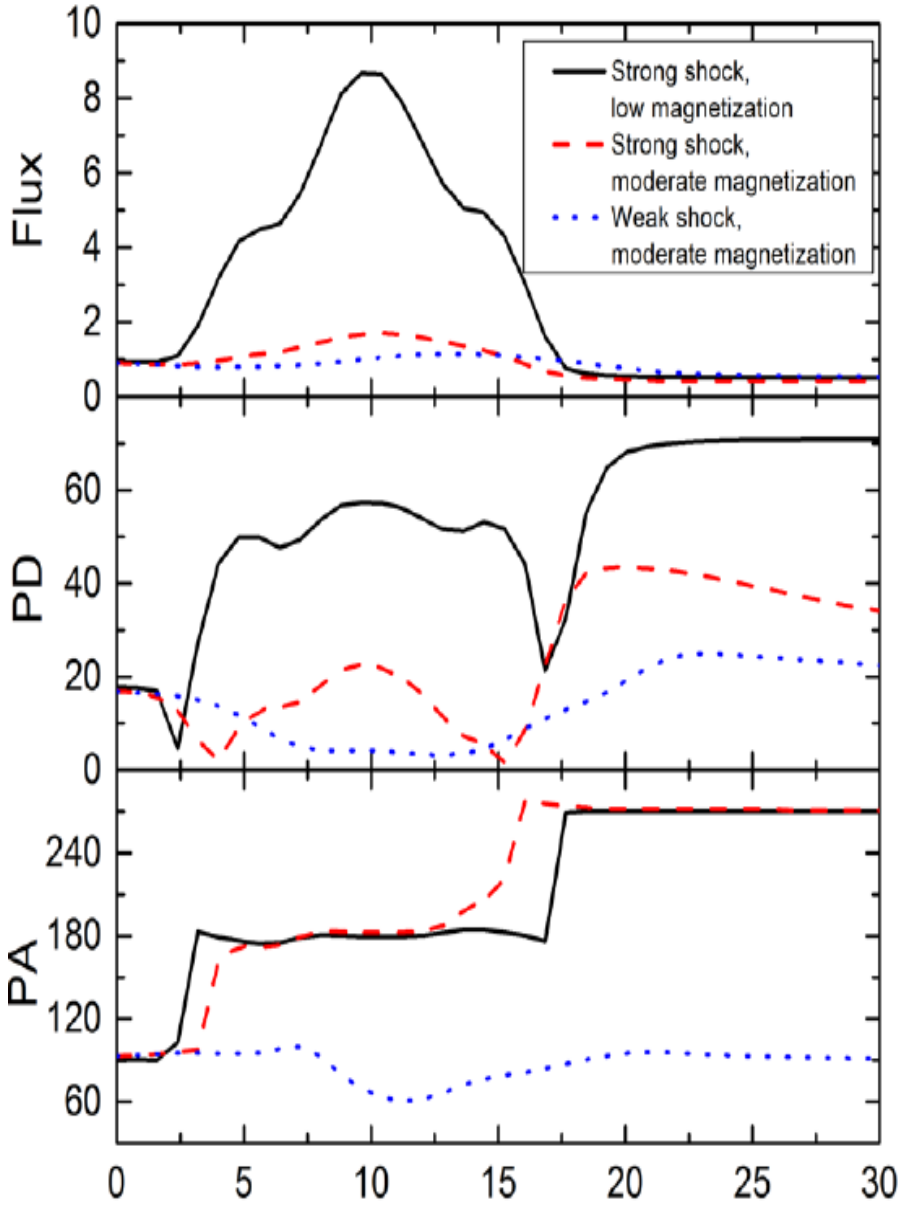
Kink





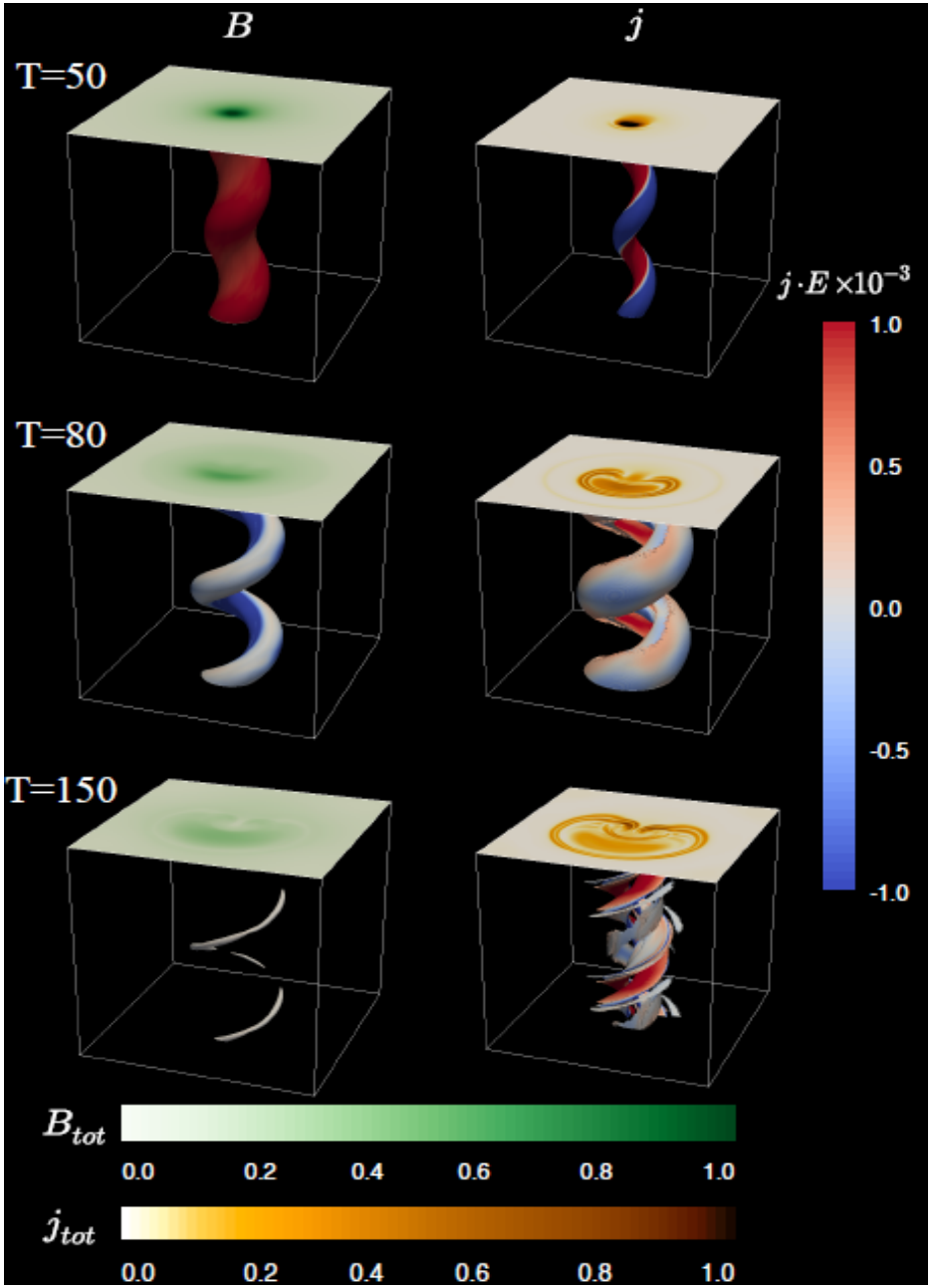
Shock Scenario

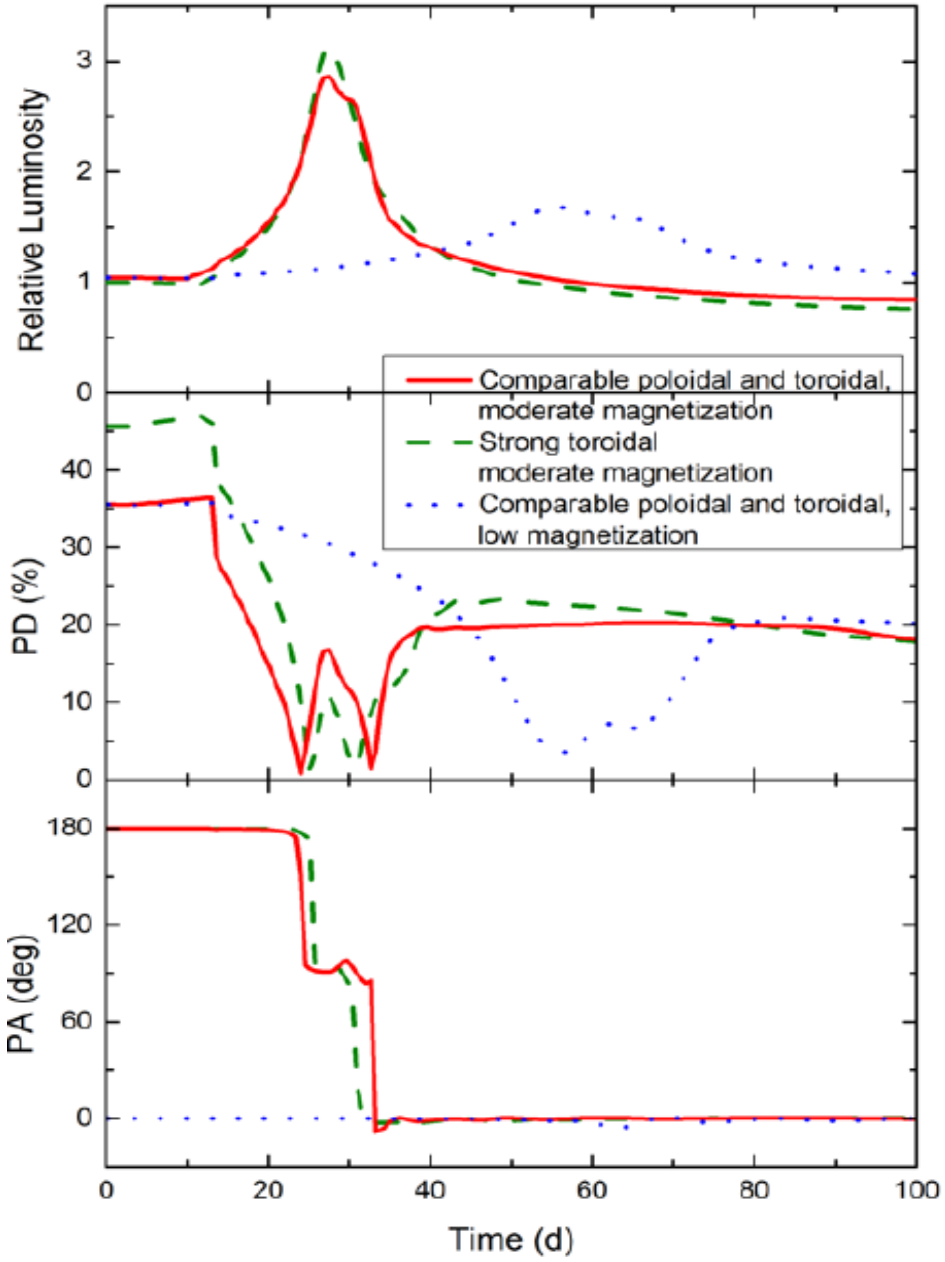




Zhang et al. 2016a

Kink Scenario





Zhang et al. 2016b

Summary

1. We perform time-dependent shock and kink simulations with detailed polarization-dependent radiation modeling
2. Our magnetic field evolution is self-consistent
3. Strong shocks can strongly compress the magnetic field, leading to strong polarization variations
4. Kink instabilities can efficiently dissipate magnetic energy and alter the magnetic topology, but the overall polarization degree is kept at a moderate level
5. In a moderately magnetized environment, laminar shocks can produce moderate polarization variation, but only make weak flares
6. Kink instability can make both strong and weak polarization variations with respectively strong and weak flares