Radiative Signatures of Relativistic Reconnection in Blazar Jets

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Blazars

- AGNs with jets pointing towards the observer
- Most abundant sources of extragalactic $\gamma$-rays (Ajello et al. 2015)
- Non-thermal, multi-wavelength emission
Blazar Variability

- Multi-wavelength variability lasting from minutes to weeks!

Quasar: 0827+243

Ackermann et al. 2016

Jorstad & Marscher 2016
Other Characteristics

Balokovic et al. 2016

Mrk 421

Jorstad & Marscher 2016
Blazar SED: FSRQ

Low-energy Bump: Synchrotron

High-energy Bump: Inverse Compton (SSC or EC)

SED: 3C 279
Blazar SED: BL Lac

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SED: Mrk 421
Can we model blazar emission?

- Short-term variability < light-crossing time
- Large Doppler factor of emitting regions > inferred bulk Lorentz factor of jet
- How do we obtain relativistic, non-thermal particles?

Animation of Magnetic Reconnection
Magnetic Reconnection & PIC

- Reconnection can:
  i. accelerate particles to relativistic energy
  ii. produce relativistically moving *plasmoids*

- Is simulated through *first-principles* particle-in-cell (PIC) simulations

Blazar Flares Via Plasmoids

Schematic Diagram of Blazar Jet

PIC Simulation of Relativistic Reconnection: density, kinetic energy, magnetic energy

Christie et al. 2018

Sironi et al. 2016
Our Emission Model

- Use 2D PIC simulation results of relativistic magnetic reconnection

- PIC governs majority of model parameter → few free parameters (e.g. B-field, external radiation fields, size of reconnection layer, strength of external radiation fields, orientation of reconnection layer)

- Compute the emission from the entire reconnection layer → model BL Lacs & FSRQs

Includes emission from Broad Line Region
Individual Plasmoid Spectra & Light Curves

FSRQ Modeling

BL Lac Modeling

Same Medium Sized Plasmoid
Fast flares, produced by medium-sized plasmoids, appear on top of a slow-evolving envelope developed by the largest plasmoids.

Christie et al. 2018

0.1 – 300 GeV Light Curve
Temporal Evolution of Layer’s Spectra

FSRQ Modeling

Jet Lorentz factor: 10
Size of Reconnection layer: $10^{16}$ cm
B-field: $4\, G$
Additional Signatures

Flaring Statistics

Increasing Plasmoid Size

- Towards Obs.
- Away Obs.

8<sup>th</sup> Fermi Symposium – Radiative Signature of Reconnection – I. Christie

Christie et al. 2018

Correlation: 0.78

Correlation: 0.89

Christie et al. in prep.
Summary

- Our fundamentally-built model displays similar spectral features in FSRQs and BL Lacs!
- Requires few free parameters
- Can produce the fast (minutes) timescale and long (days) flares observed in many blazars!

Outlook

- Numerous comparisons with observations (e.g. PSDs, correlation, flaring statistics) to come! (Christie et al., in prep.)
- Inclusion of Hadronic components within model to determine potential neutrino flux (Christie et al., in prep.)

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