Characterizing leptonic long-term variability in blazars

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Monitoring the non-thermal Universe
17 – 21 August 2018

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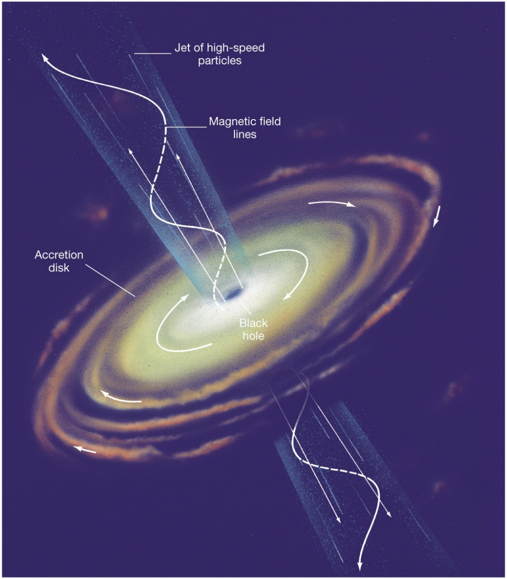
Blazars



Jet of high-speed particles
Magnetic field lines
Accretion disk
Black hole

Motivation

- Blazars exhibit rapid varying emissions.
- Extensive effort in multiwavelength observations.
- Most research focuses on individual flares.
- Continuous observations in i.e. X-ray and γ-ray wavebands presents the opportunity to study the long-term variability.

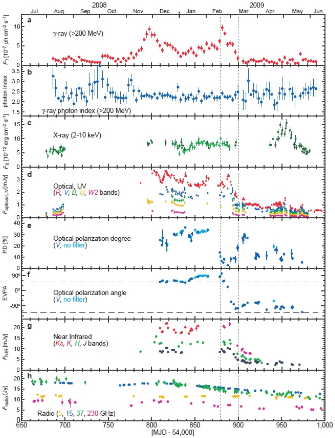


Figure: Fermi-LAT Collaboration & 3C 279 multi-band campaign (2010).

Aim

- Modelling long-term variability to better understand causes of such phenomenon
- Use long-term variability as a tool to improve on models.
- Construct parameter varaitions representative of accretion flows.
- Identify specific behavior from resulting multiwavelength curves, PSDs and cross-correlations.

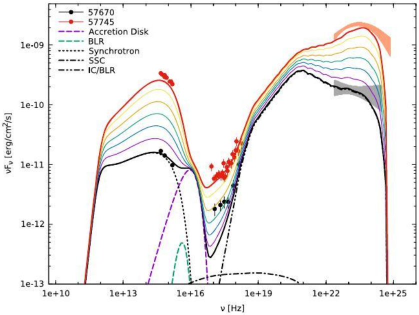
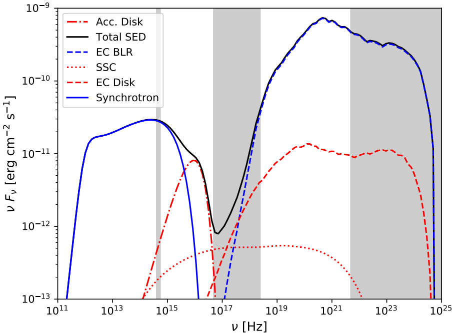


Figure: Zacharias et al. (2017)

Model and Setup

Time-dependent one-zone leptonic model (Diltz and Böttcher, 2014) used. Baseline parameters used are similar to the work of Zacharias et al. (2017).

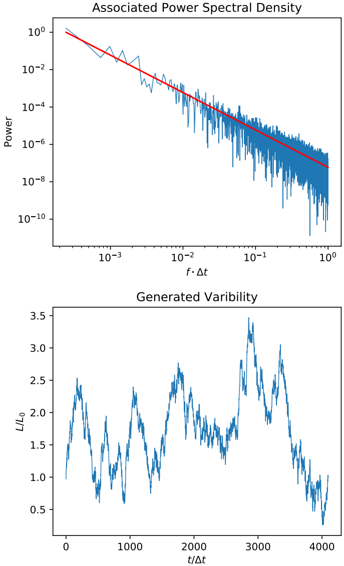
- Low-frequency peak in emission caused by synchrotron.
- High-frequency peak due to inverse Compton scattering.



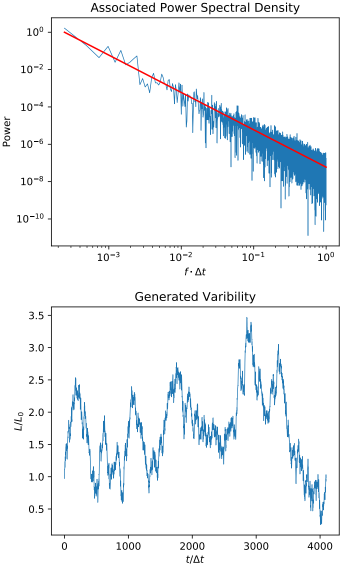
Generating Variations

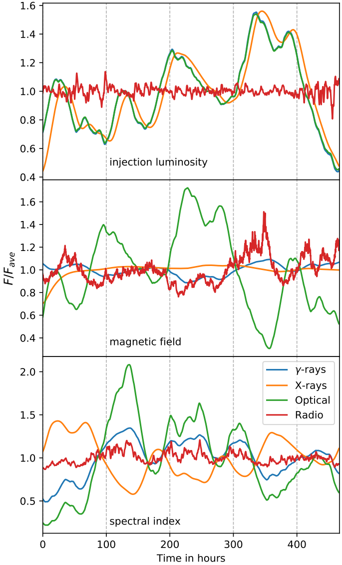
- PSDs are generated with the algorithm of Timmer and König (1995) from which a signal can be obtained.
- The signal is then used as input for the model for a specific parameter.

$$P(f) = \mathcal{N}(0, S(f)) + i\mathcal{N}(0, S(f))$$
$$x(t) = \mathrm{FFT}\{P(f)\}$$

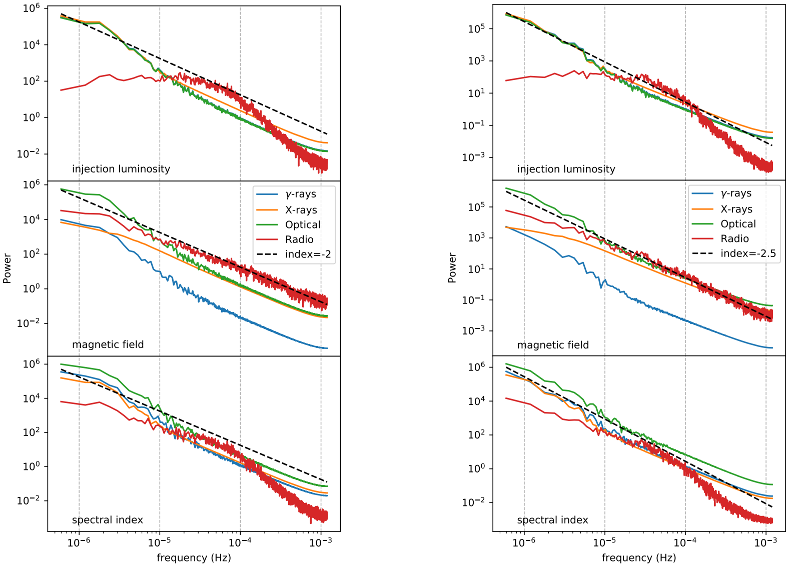


Results: Light curves

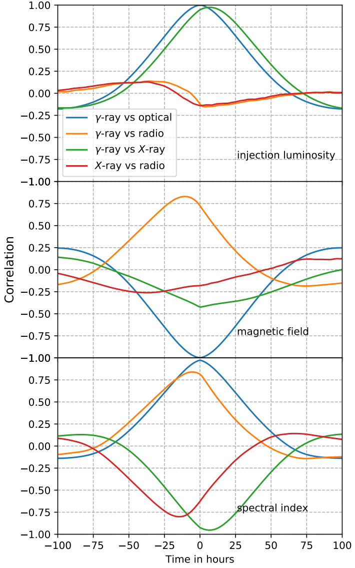




Results: PSD averages



Results: Cross-correlations



Injection Luminosity		
γ-ray vs optical	(0.06, 1.00)	max
γ-ray vs radio	(3.20, -0.15)	–
γ-ray vs X-ray	(6.70, 0.98)	max
X-ray vs radio	(0.06, -0.14)	–

Magnetic field		
γ-ray vs optical	(0.06, -1.00)	min
γ-ray vs radio	(-10.54, 0.83)	max
γ-ray vs X-ray	(0.06, -0.43)	–
X-ray vs radio	(-37.23,-0.26)	–

Spectral index		
γ-ray vs optical	(0.06, 0.97)	max
γ-ray vs radio	(-5.53, 0.84)	max
γ-ray vs X-ray	(6.70, -0.95)	min
X-ray vs radio	(-14.51,-0.80)	min

Current & future work

- Find explanations for some results.
- Explore more input PSD spectra and parameters.
- Explore SSC dominated representative test case.
- Use the same methodology for hadronic model.
- Characterizing variability patterns in real observations of blazars.

Questions

Thank you

Questions are welcome and appreciated

This work is funded by the NRF. Any opinion, finding and conclusion or recommendation expressed in this materisal is that of the author, and the NRF does not accept any liability in this regard.

References

Diltz, C. and Böttcher, M. (2014). Time dependent leptonic modeling of fermi ii processes in the jets of flat spectrum radio quasars. *Journal of High Energy Astrophysics*, 1-2:63–70.

Timmer, J. and König, M. (1995). On generating power law noise. *Astronomy and Astrophysics*, 300:700.

Zacharias, M., Böttcher, M., Jankowsky, F., Lenain, J. P., Wager, S. J., and Wierzcholska, A. (2017). Cloud ablation by a relativistic jet and the extended flare in cta 102 in 2016 and 2017. *Astrophysical Journal*, 851:72.