Characterizing long-term leptonic variability in blazars

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Abstract

Most research in blazar variability focuses on individual flares to explain acceleration and radiation mechanisms and improve on current models. These short-time events (minutes, hours or days) might not be representative of the underlying mechanisms causing small- amplitude variability and/or continuous emission present most of the time. We therefore investigate long-term (month to years) variability of blazar emission in the framework of current leptonic blazar models. For this purpose, we introduce generated time- dependent parameter variations which are based on typical Power Spectral Densities (PSDs) associated with the variability of accretion flows. The PSDs from the resulting light curves are analysed and compared to one another as well as the PSD of the variation PSD. Correlations between light curves are also investigated to aid identification of characteristic variation patterns associated with leptonic models. The resulting multi-wavelength PSDs were found to follow the input variation PSD trend closely, however, it presented no clear distinctions between the varied pa- rameters. The multi-wavelength cross-correlations showed significant difference among the varied parameters. We therefore conclude that the PSDs are plausible candidates for extracting the variational trends of variability progenitors while multi-wavelength cross-correlations would be a plausible diagnostic for identifying radiative mechanism characteristics as well as the varying quantity in the emission region.

Introduction

Blazars are a subclass of active galactic nuclei (AGN) for which matter is accreted onto a super massive black-hole (SMBH) that forms highly relativistic, collimated jets of particles moving closely to our line of sight leading to highly Doppler boosted emission.

Variability in the emission of blazars are a ubiquitous observed property, however the source of this rapid changes are not well understood.

This work simulates leptonic variability in flat spectrum radio quasar (FSRQ) and BL Lac object (HBL) represenatative blazars and investigates the long-term behaviour to identify characteristic variability signatures.

Model and Setup

Time-dependent variations are generated [Timmer and König, 1995] that is representative of variability of accretion flows ($P \propto f^{-\alpha}$ with P the power and f the temporal frequency and $\alpha = -2$ the index) to simulate variability.

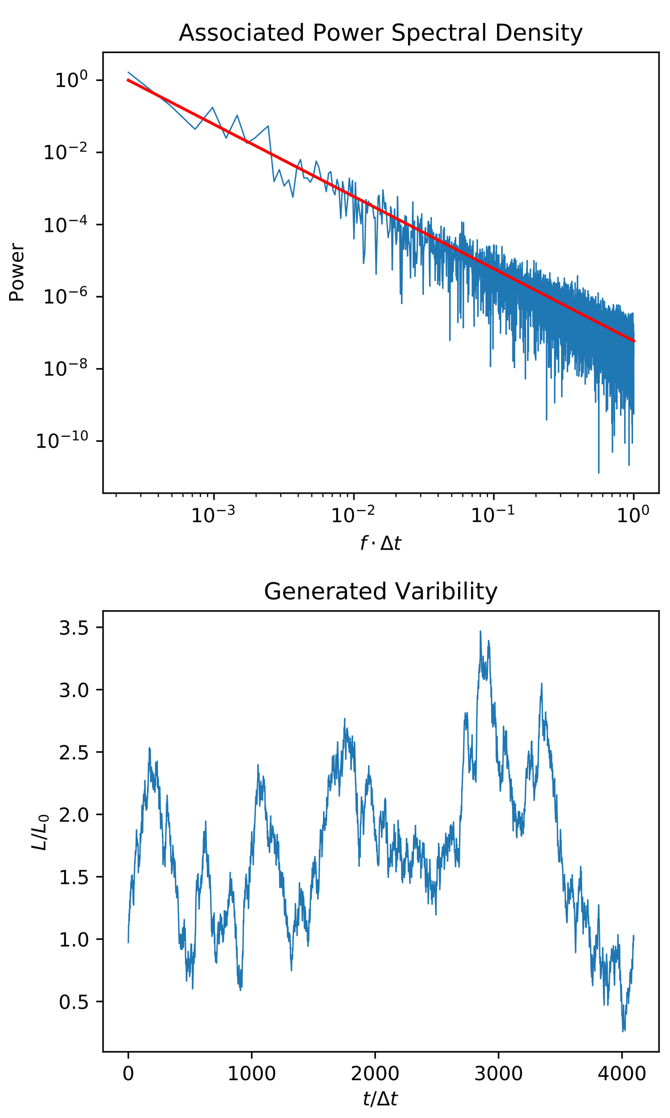

Figure 1: Typical generated variation adapted for injection luminosity generated from the PSD with an index $\alpha = -2$.

The time-dependent variations are then introduced into a time-dependent one-zone leptonic model [Diltz and Böttcher, 2014, Zacharias et al., 2017] as a variation of on of three parameters (injection luminosity, magnetic field strength, electron spectral index) in the emission region.

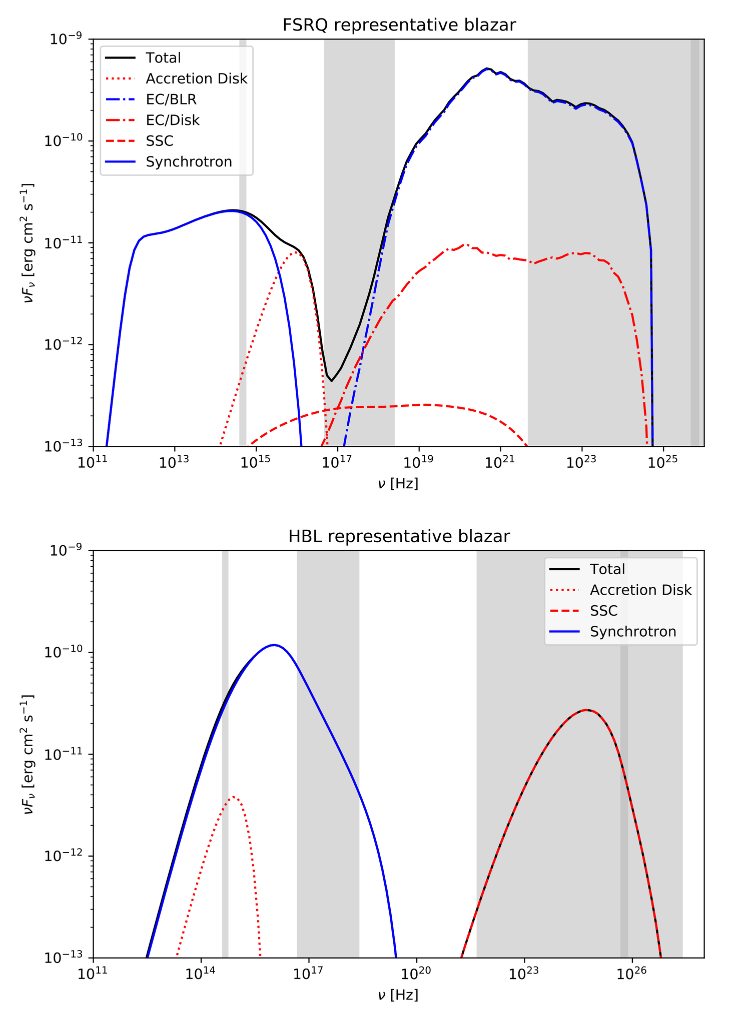

Figure 2: Representative blazar SEDs. Shaded areas indicate light curve ranges.

Results

PSDs

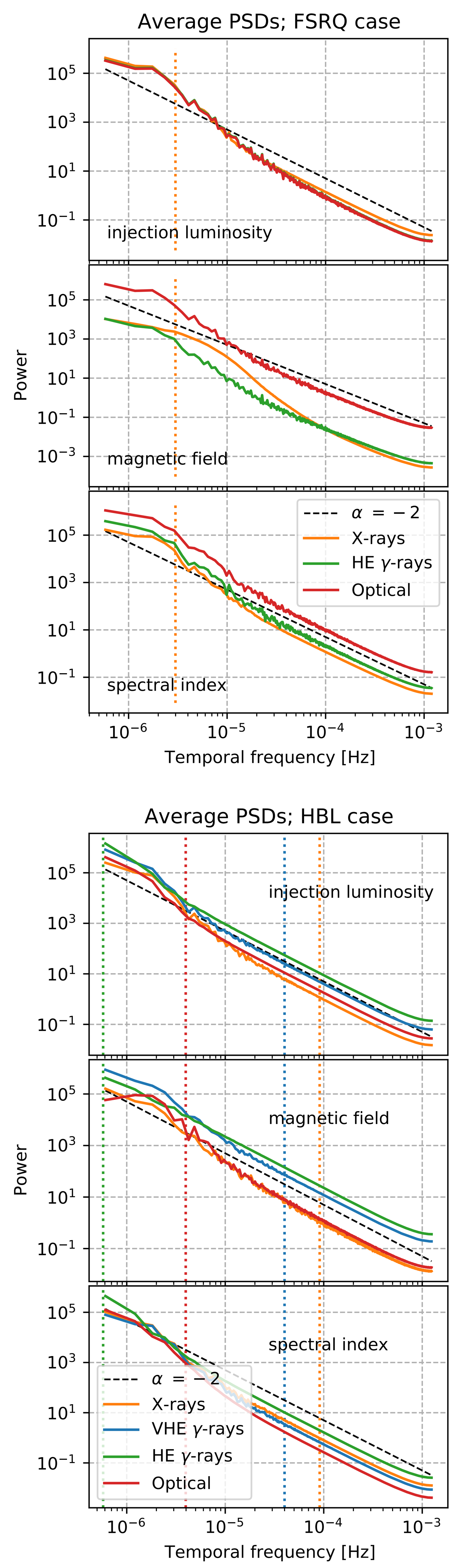

Figure 3: Light curve PSDs. Vertical dotted lines indicate characteristic cooling frequencies.

Cross-correlations

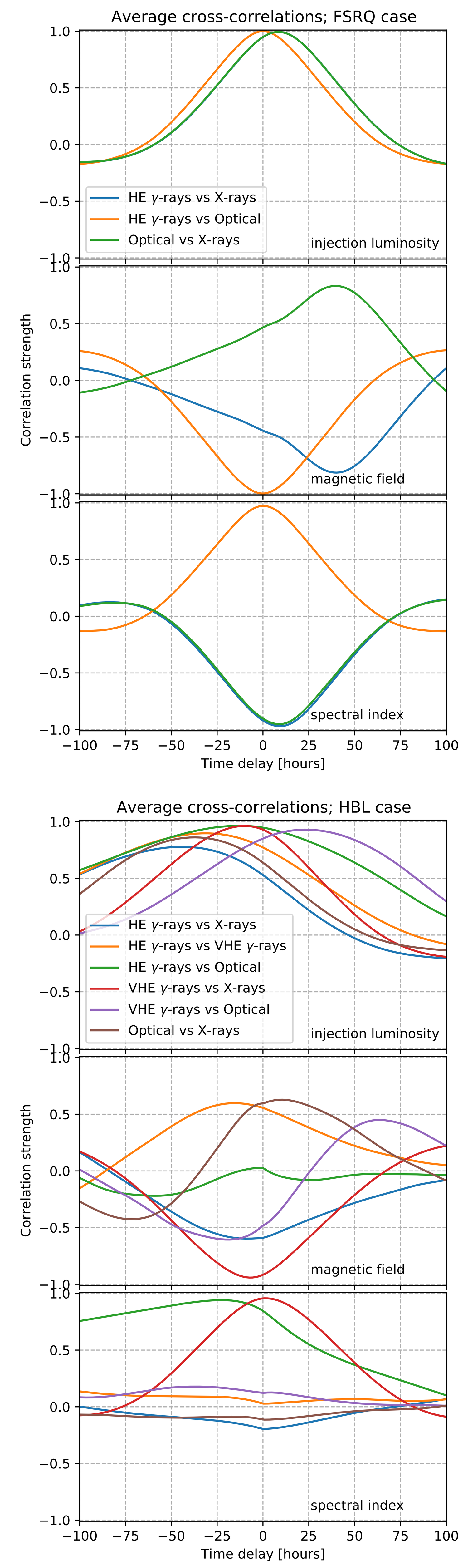

Figure 4: Multi-wavelength light curve cross-correlations.

Discussion and Conclusions

The light curve PSDs were found to follow the underlying variation PSD index ($\alpha = -2$) closely. Significant distinctive features e.g. index breaks, QPO's, etc. across the different cases tested were not found. It could therefore be a plausible diagnostic to probe stochastic nature of underlying variations producing observed variability

The multi-wavelegth cross-correlations show significant distinctive differences for the different varied parameters. The differences between the different blazar cases lies in the correlation time delays which is just a consequence of a difference in cooling-time scales. This shows that the cross-correlations will help to identify changing parameters and emission mechanisms in blazars that lead to observed variability.

References

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