Optical variability studies of gamma-ray emitting blazars

Abstract: Variability studies of blazars have identified in the past hints of quasi-periodic emission for different sources, although strong evidences are still lacking. The understanding of whether this emission is truly periodic or not can help to explain the structure of blazars and the emission mechanisms taking place in these objects.
We present the results of the periodicity analysis in the optical band of the gamma-ray blazars 3C 66A and B2 1633+38 with light curves spanning more that a decade. Three well-known tools commonly applied in periodicity studies have been used: the Lomb-Scargle periodogram, the Z-transform Discrete Correlation Function and the Weighted Wavelet Z-transform. We have found significant evidences of long-term periodicity in these sources, with periods of several years. The study was complemented with the periodicity analysis of the gamma-ray light curves. The results are interpreted within the framework of blazar emission models.

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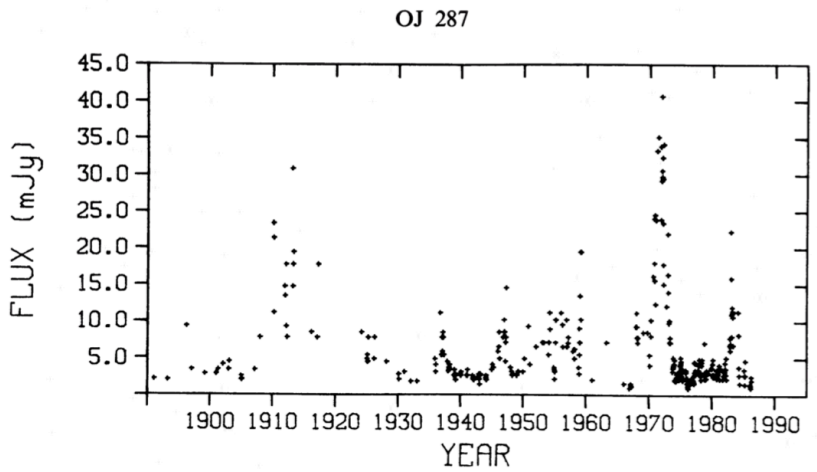
Context

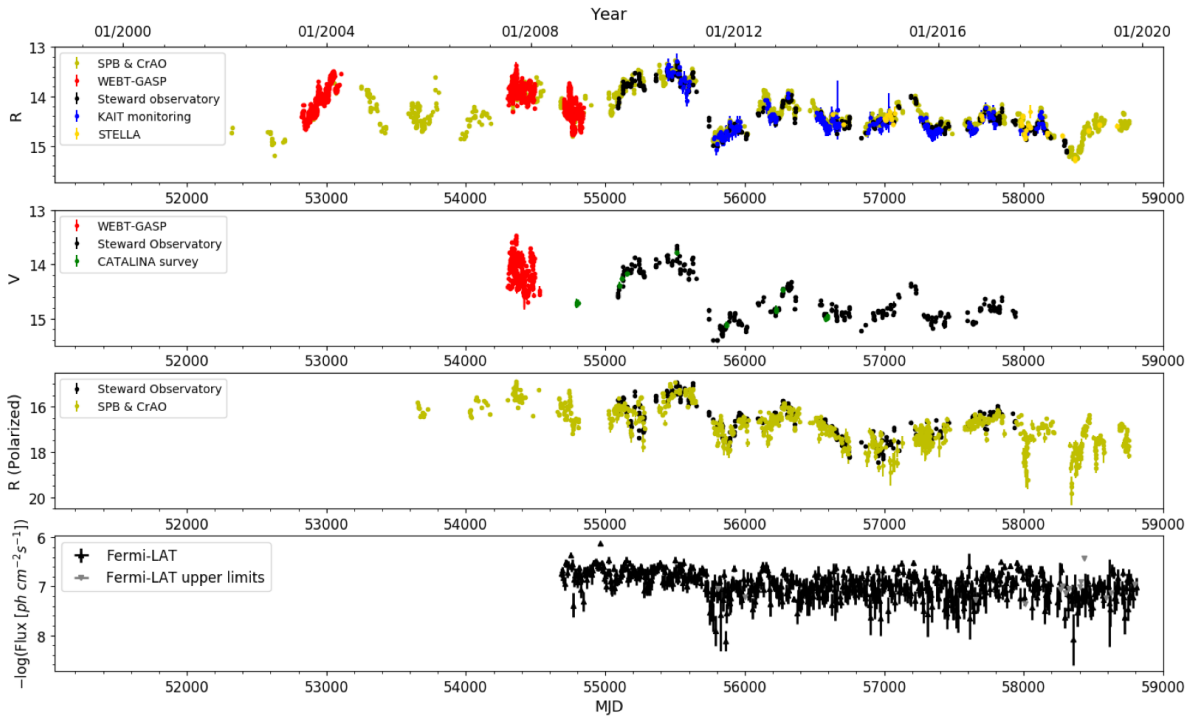
- **Blazars**: radio loud AGNs with relativistic jets pointing in the direction of Earth
- Strong **variability** throughout all the electromagnetic spectrum
    - Minutes to hours: intraday variability
    - Days to weeks: short-term variability
    - **Months to years: long-term variability**
- Variability and quasi-periodicity studies have great importance to understand the physical processes taking place in jets and black hole accretion disks in active galaxies

OJ 287 historical light curve
Possible period of ~11.65 years detected by
Sillanpää et al. 1988

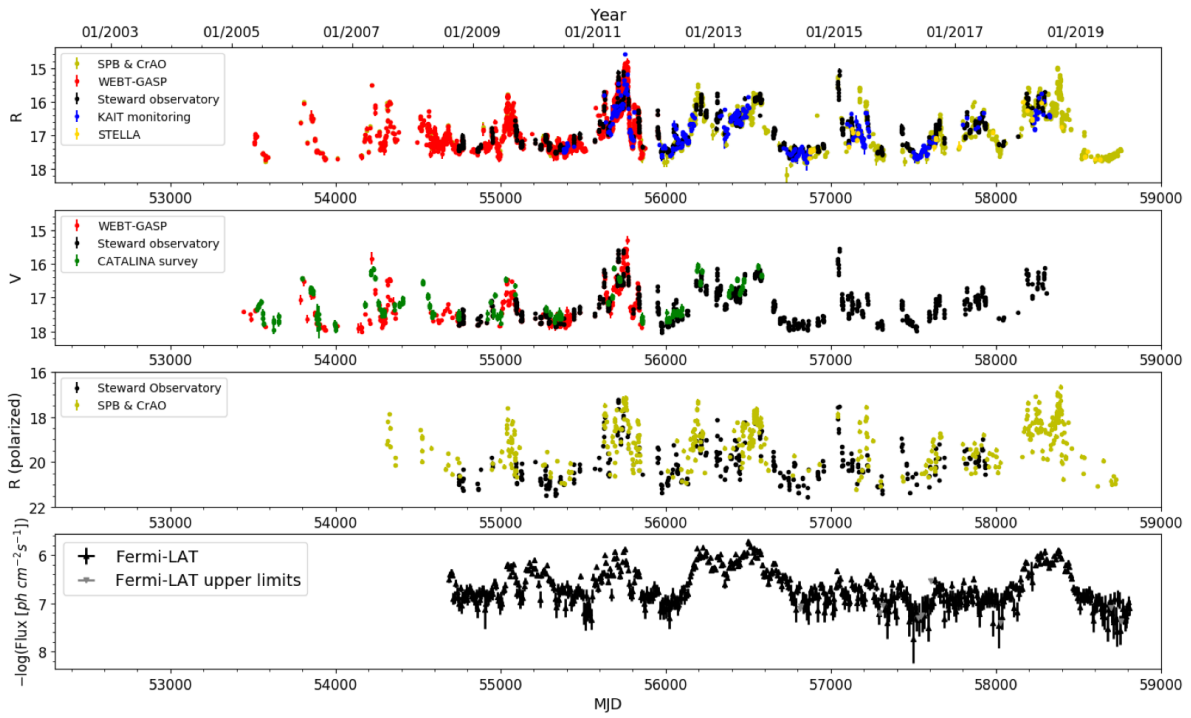


Methodology

Data collection:
Steward Observatory, WEBT-GASP, St. Petersburg University, Crimean Observatory, Catalina Survey, KAIT telescope, STELLA telescopes, *Fermi*-LAT (gamma-rays)



3C 66A (BL Lac)



B2 1633+38 (FSRQ)

Z-Discrete Correlation Function (ZDCF)
Lomb-Scargle periodogram (LS)
Weighted Wavelet Z-transform (WWZ)

Results

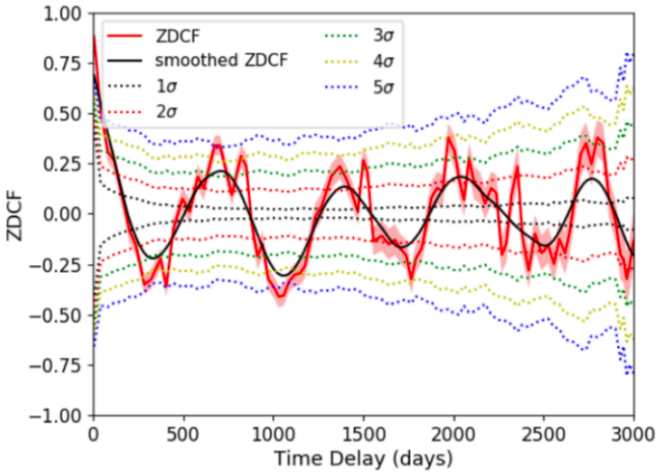
B2 1633+38 optical V band results

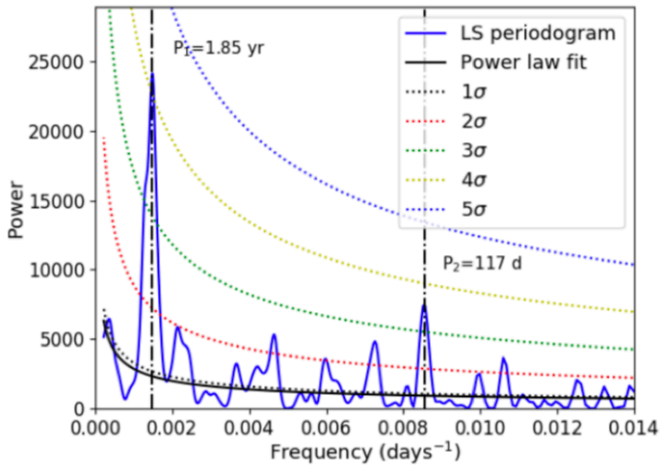
B2 1633+38 (FSRQ):

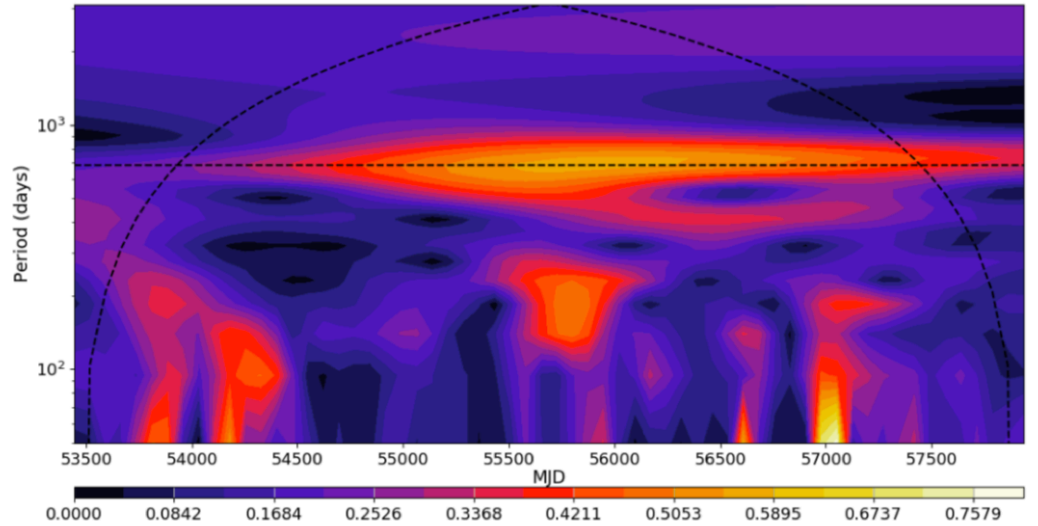
- **Periodic variability** in both the **total and polarized optical flux** (~1.9 years, 3-5σ significance), consistent with Raiteri et al. (2012).
- **Possible hint in gamma-rays** (2-3σ significance)

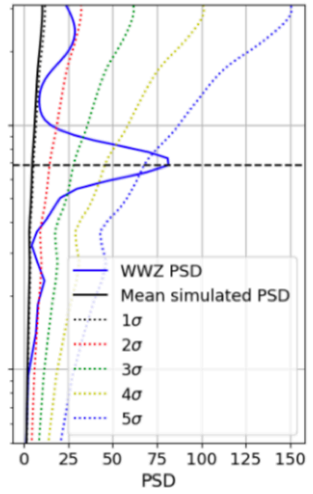
3C 66A (BL Lac):

- **Periodicity** in the **total optical flux** (~3 years, 3-5σ significance)
- **No periodicity** in the **polarized flux** or in the **gamma-ray band**





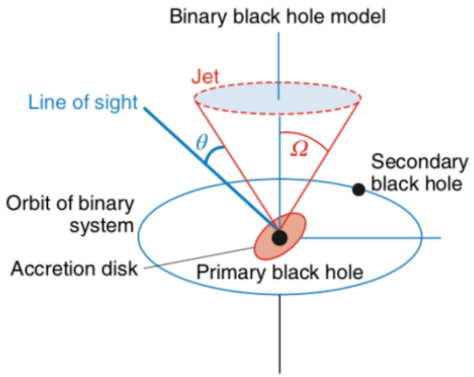


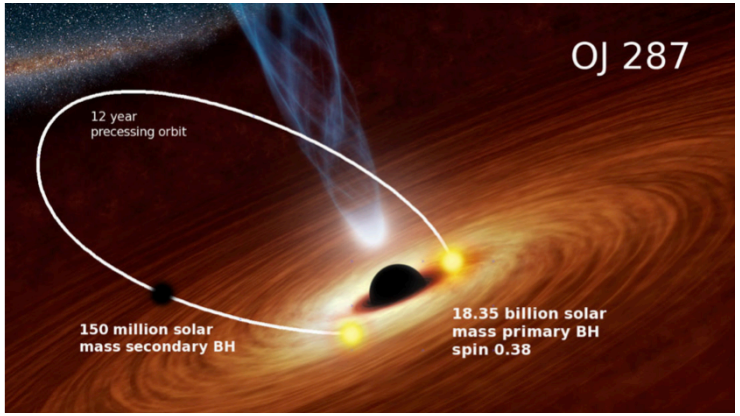


Otero-Santos et al. 2020

Possible scenarios

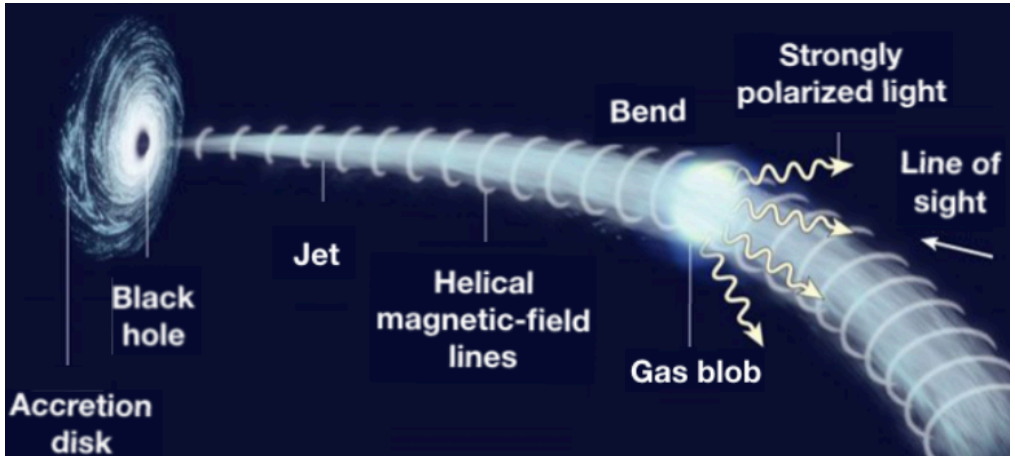
- Presence of a **supermassive binary black hole** (SBBH; disfavoured by predictions and observations)





SBBH representation (Abraham 2018 / AAS 2018)

- **Variations in the jet emission mechanism** due to helical structures in the jet, relativistic shocks, instabilities…

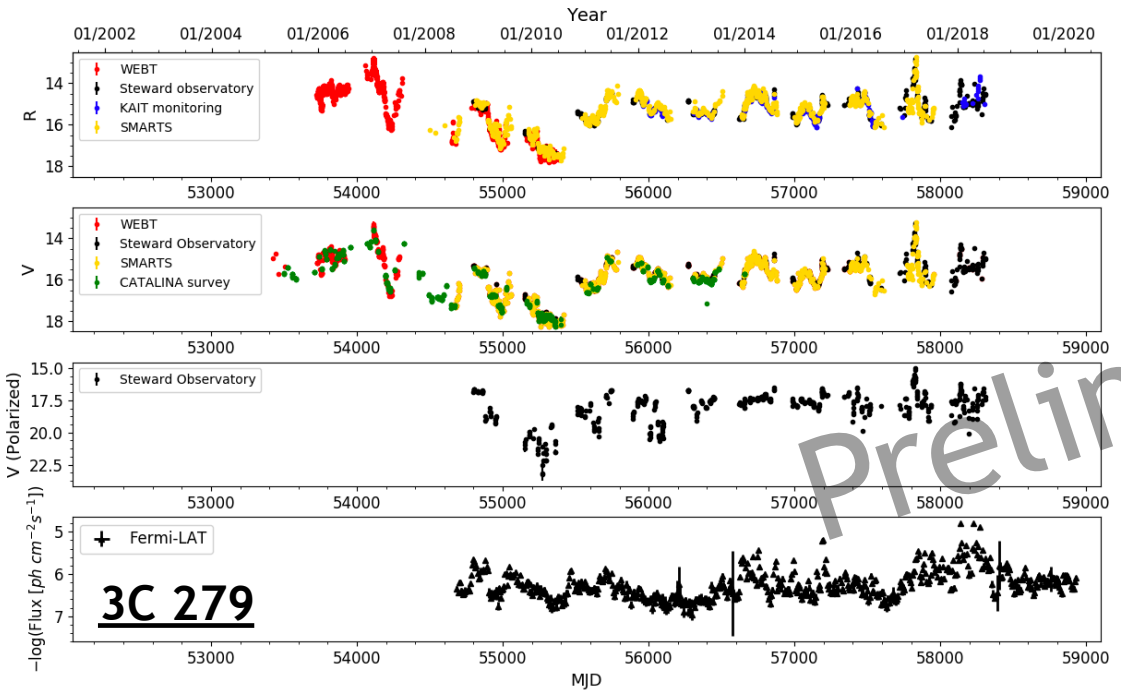


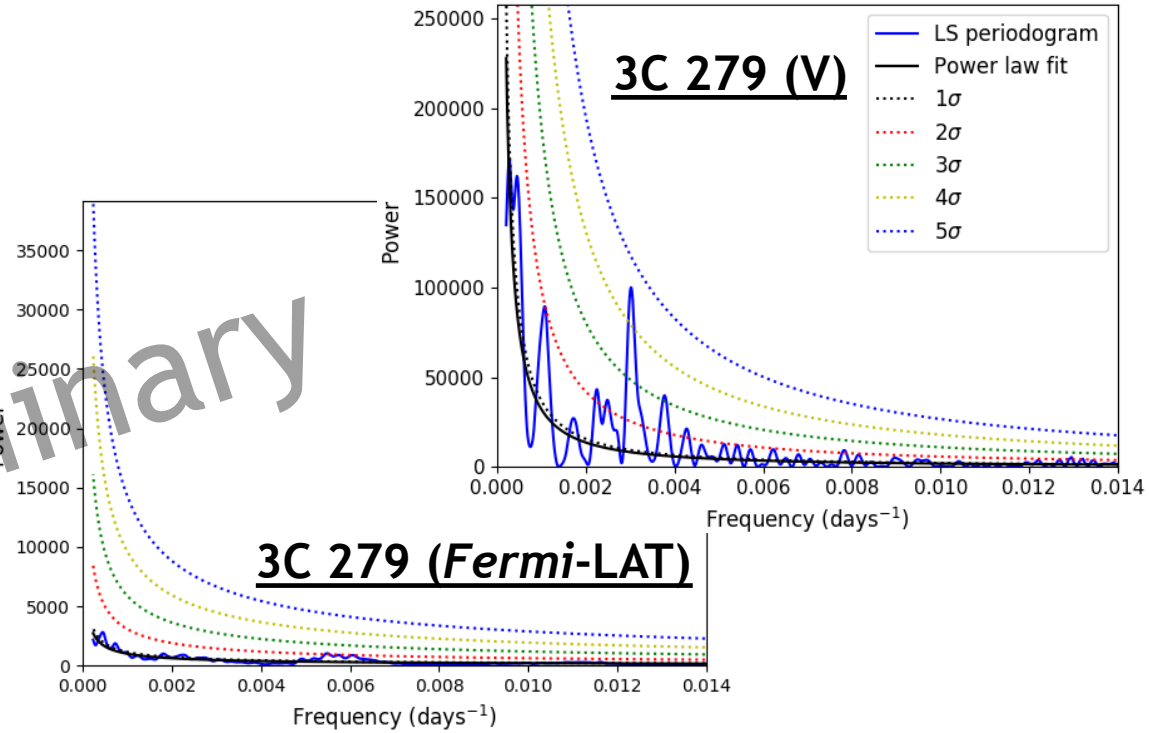
Helical jet model with different emission mechanisms (Young 2010)

Impact & future steps

- **First evidence of periodicity in the optical band of B2 1633+28**
- **First periodicity analysis for the polarized optical flux**
- **Different models** proposed to explain the quasi-periodic variations
- Future steps: Extend the analysis to a larger sample of sources

→ Otero-Santos et al., 2020, MNRAS, 492, 5524





Preliminary