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imma-ray Space Telescope



# Search for binary SMBHs in Gamma-ray Blazars



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### Introduction





- AGN: variability in the overall electromagnetic spectrum
- Pattern → **Periodicity**
- Different strategies in the literature:
  - one object by means of a few (two) analysis algorithms
  - cross-correlation with other data of different wavelength







- *Fermi*-LAT (launched 11th July 2008)
- Fast Orbit (95 min) Large field of view (2 sr)

Monitoring Sources (scanning the sky each 3 hours)

Detect γ rays by producing an electron-positron pair in the detector
Energies ranging: ≈ 20 MeV - ≥ 300 GeV





- $\approx$ 2000 AGN (3FGL+2FHL+3FHL catalogs)
- 21st August 2008 7th September 2017
- Light-curve monthly binned: 28 days
- Data processing:
  - Integral Energy Flux above 1 GeV
  - Energy Flux Upper limits for TS<4  $\approx 2\sigma$



















REDFIT

Schulz and Mudelsee, 2002



















- All of them have drawbacks and advantages VanderPlas J., 2018 Goyal, A., et al. 2017
- Potential results comparison































- 4 methods with a same period peak with  $\geq 4\sigma$
- 11 AGN as candidates to have periodic gamma-ray emission (our "Golden list"):
  - 2 previously reported (PG 1553+113 & PKS 2155-304)
  - 9 new candidates

TXS 0518+211



 $2.8 (> 3\sigma)$ 



## **Results (I): Candidates in the Literature**









- 13 low-significance candidates
  - $\sim$  3 methods with a same period peak with  $\geq 4\sigma$
- False-Detection Periodicity Rate:  $\approx 1$  fake detection
- $5\sigma$  exposure estimation: range 2-4 years
- The impact of upper limits in LCs:
  - significance: 10%-40%
  - period: 5%-30%
- Multiwavelength Analysis:
  - KAIT, SMARTS, OVRO..
  - Cross-Correlation
  - Periodicity Study





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- Characterization of the candidates:
  - $\circ$  prediction of high-activity states  $\rightarrow$  monitoring
  - SED





- Candidates observables with 45° over zenit:
  - $\circ$  4 only from the North
  - 3 only from the South
  - 4 from both hemispheres



- Separation parsec scales:
  - FMgII/FCIV up to one order of magnitude smaller than single black holes.
  - $\circ$  F<sub>MgII</sub>/F<sub>H</sub> may be significantly reduced only at the shortest separations





- Systematic search of gamma-ray periodicity in ≈2000 *Fermi*-LAT AGNs studied over a period of 9 years
- 11 gamma-ray periodicity candidates
  - 9 new candidates
  - 2 previously reported in the literature
- 13 low-significance candidates
  - 10 new candidates
  - 3 previously reported in the literature
- On-going:
  - Multi-Wavelength study
- Sinergy:
  - IACTs: monitoring and characterization of the candidates
  - GTC: spectroscopy study in the optical/IR range