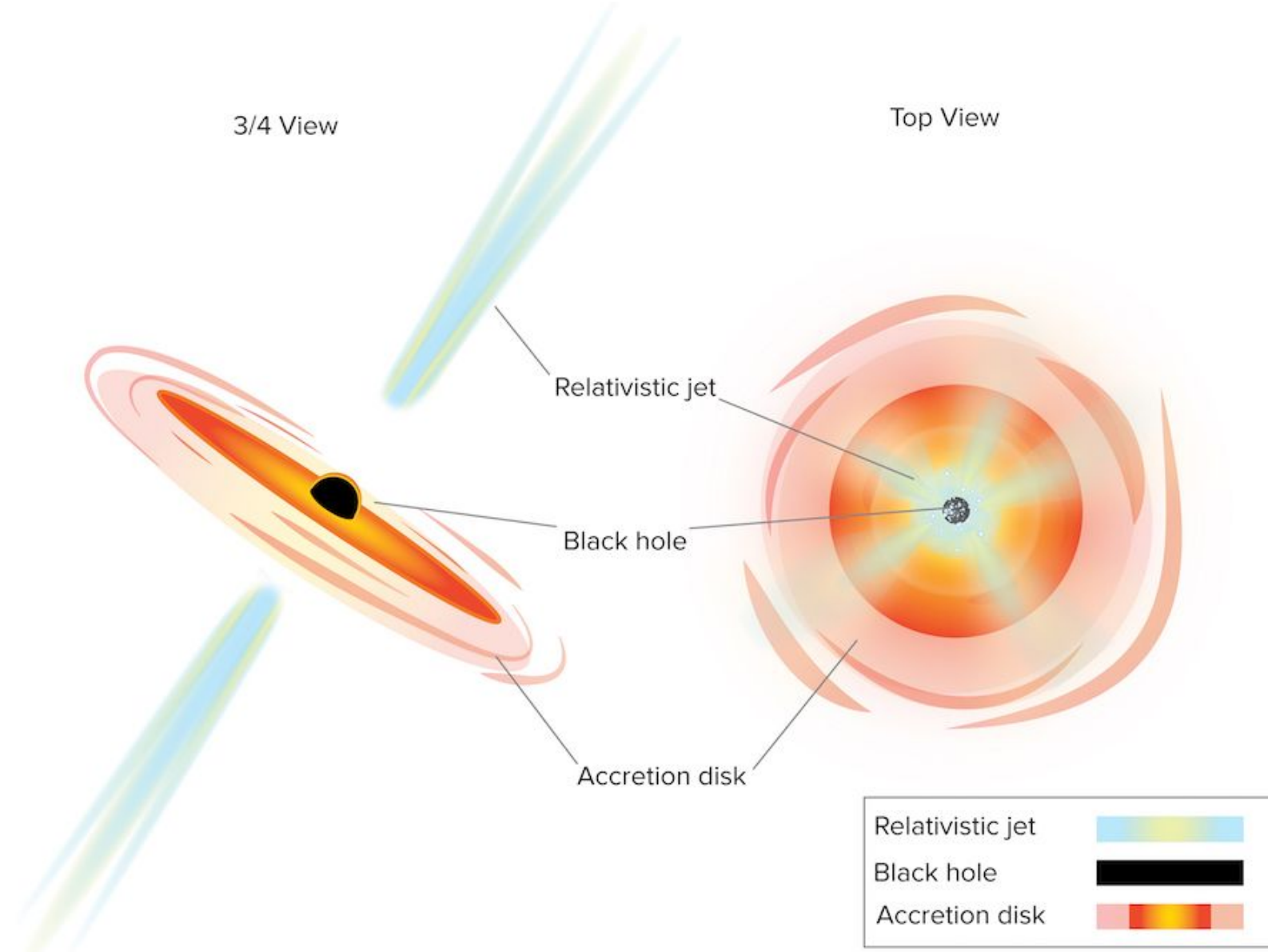




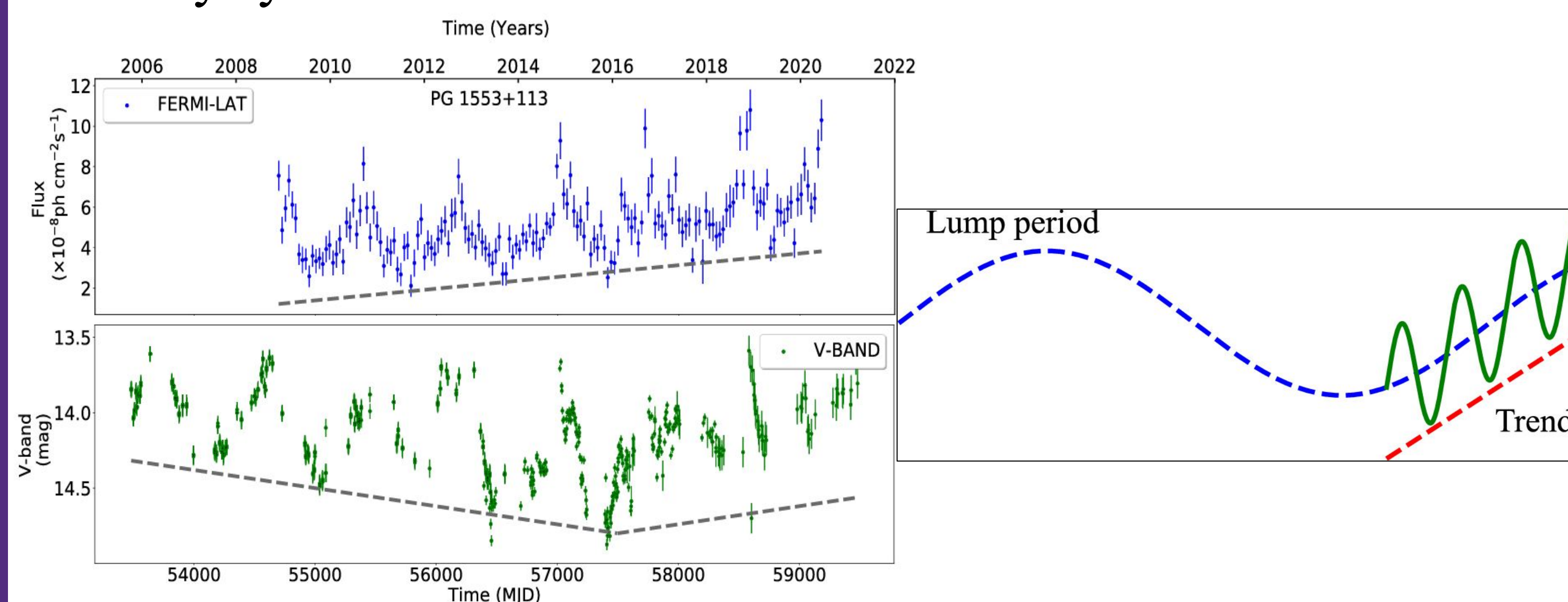
## What is a Blazar?

- Active galactic nuclei (AGNs) that point the jets towards us are called blazars.
- Blazars from the 2FHL catalog have been detected at 50 GeV - 2 TeV.
- PG 1553+113 is one of the most studied blazars for periodicity and a binary supermassive black hole (SMBH) candidate†.



## Why is PG 1553+113 important?

- Peñil et al. 2024 noticed a rising trend in the multiwavelength light curve (LC) of PG 1553+113 including at  $\gamma$ -rays with Fermi-LAT.
- Can this trend be part of a longer term oscillation?
- If yes, can these simultaneous oscillations be generated by a binary system?

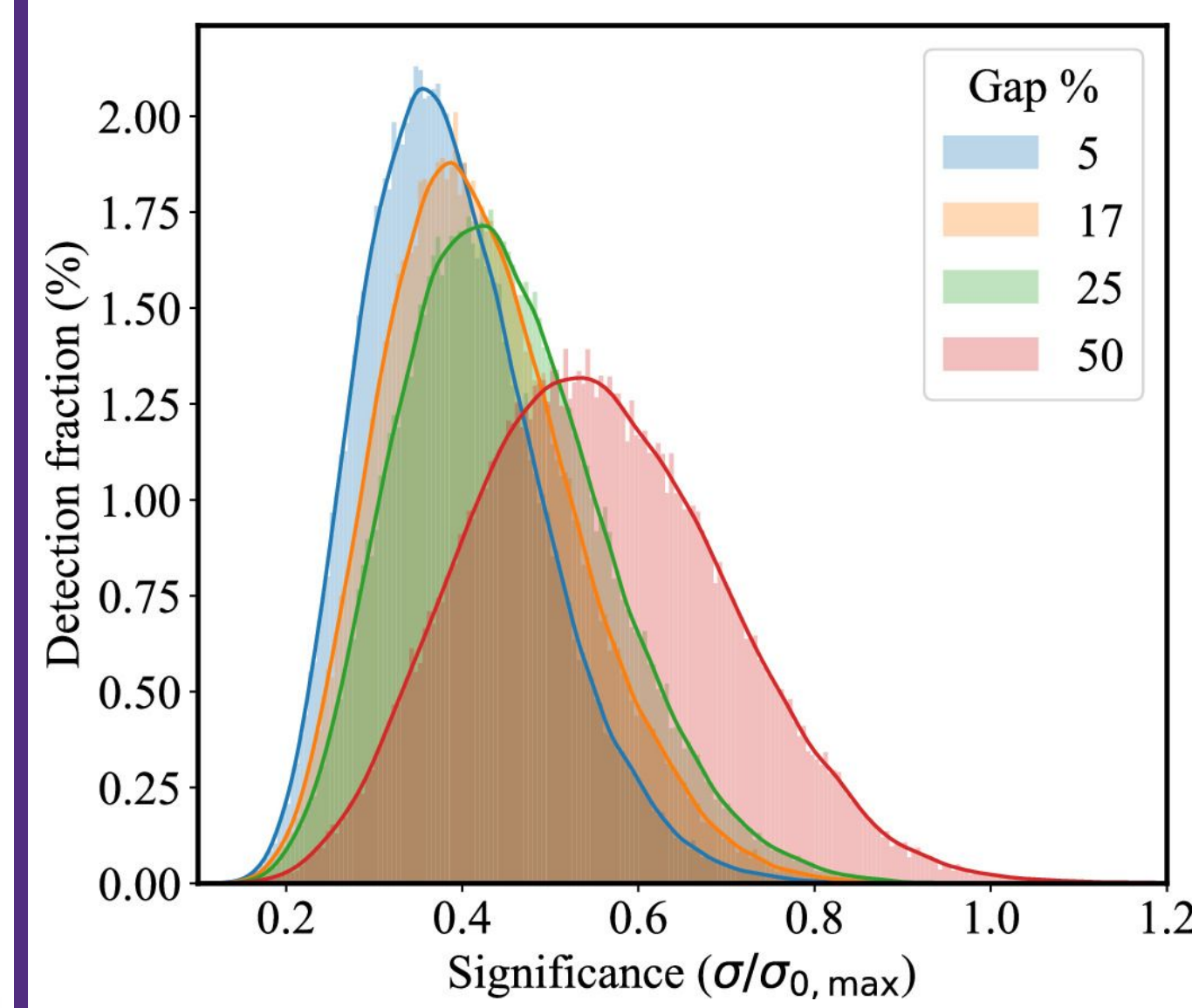


- Can "irregular sampling" produce false periods?
- Can the "Lump hypothesis" explain double periods?
  - Lump hypothesis refers to an orbiting overdensity in the circumbinary disk that modulates the accretion rate to the black holes on a timescale of 5–10 binary orbits.

## How do we study the LC?

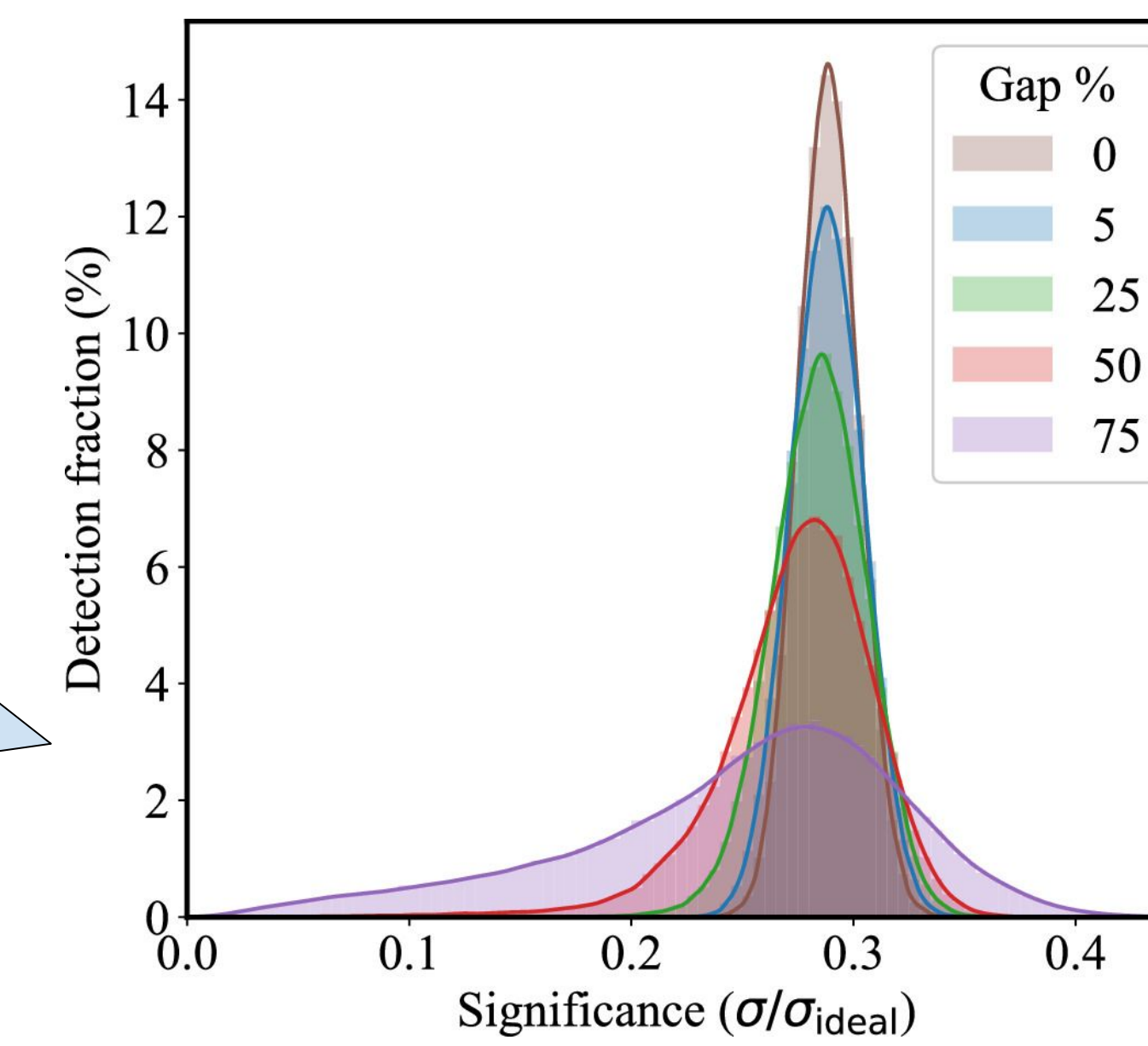
- Generalized Lomb-Scargle periodogram (GLSP).
- Wavelet analysis (WWZ).
- Impact of gaps in the LC on false periods and significances.
  - By generating artificial LCs with statistical properties matching the original LC.

## Results

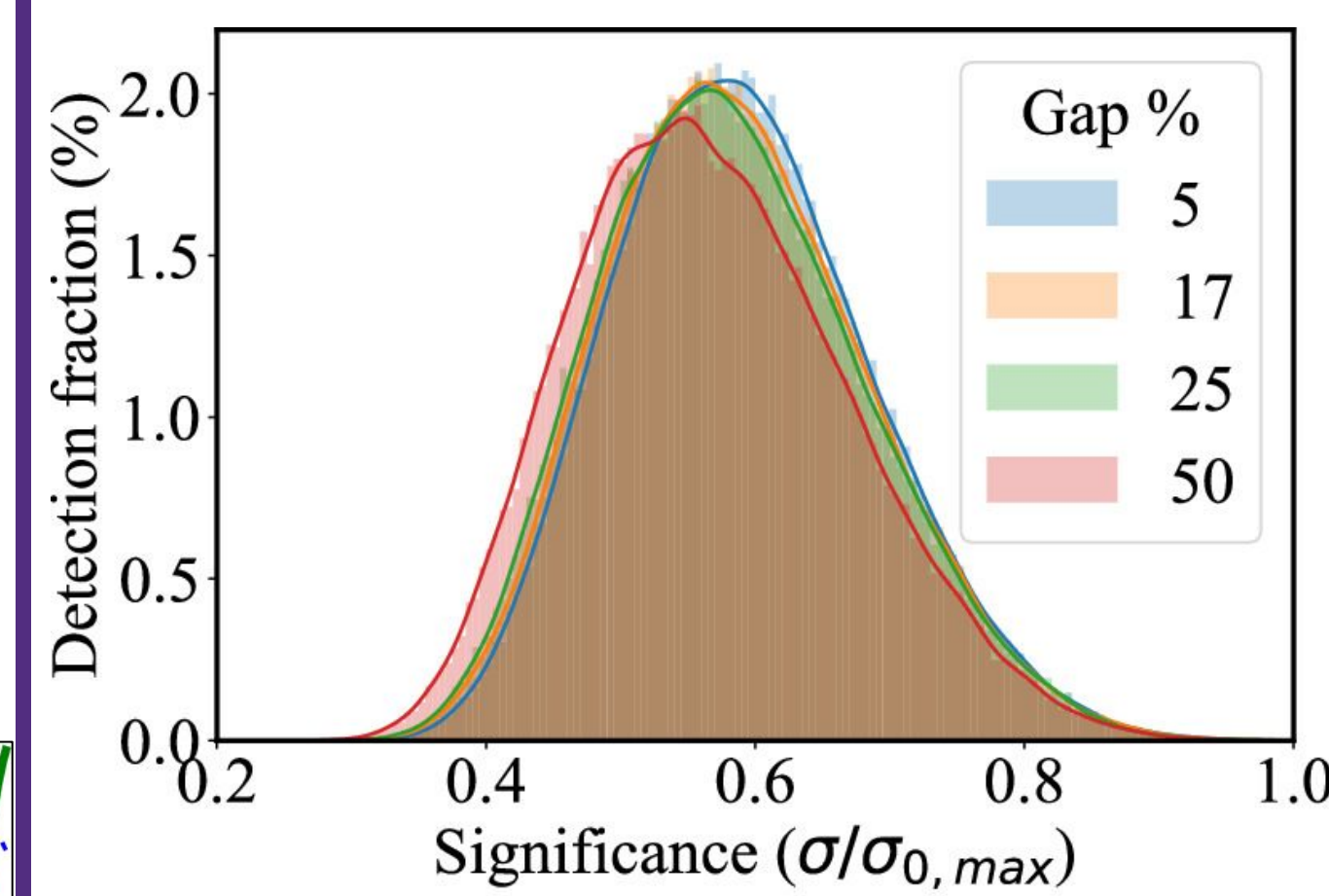


For white noise LCs with different fraction of gaps, the significance of false periods increases with the gap fraction.

For periodic LCs with different fraction of gaps, the significance of false periods does not increase with the gap fraction.



For PG 1553+113-like LCs with different fraction of gaps, the significance of false periods does not increase with the gap fraction!

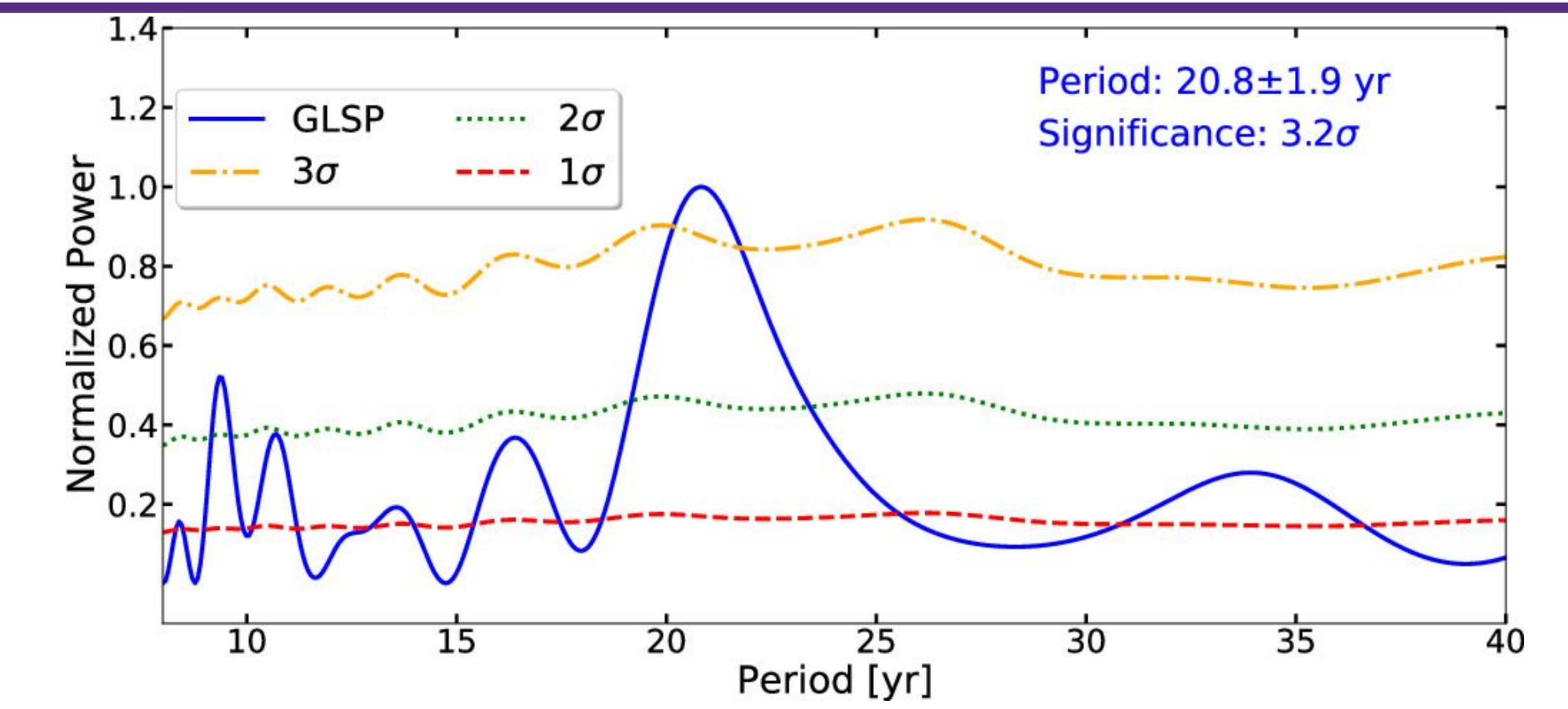
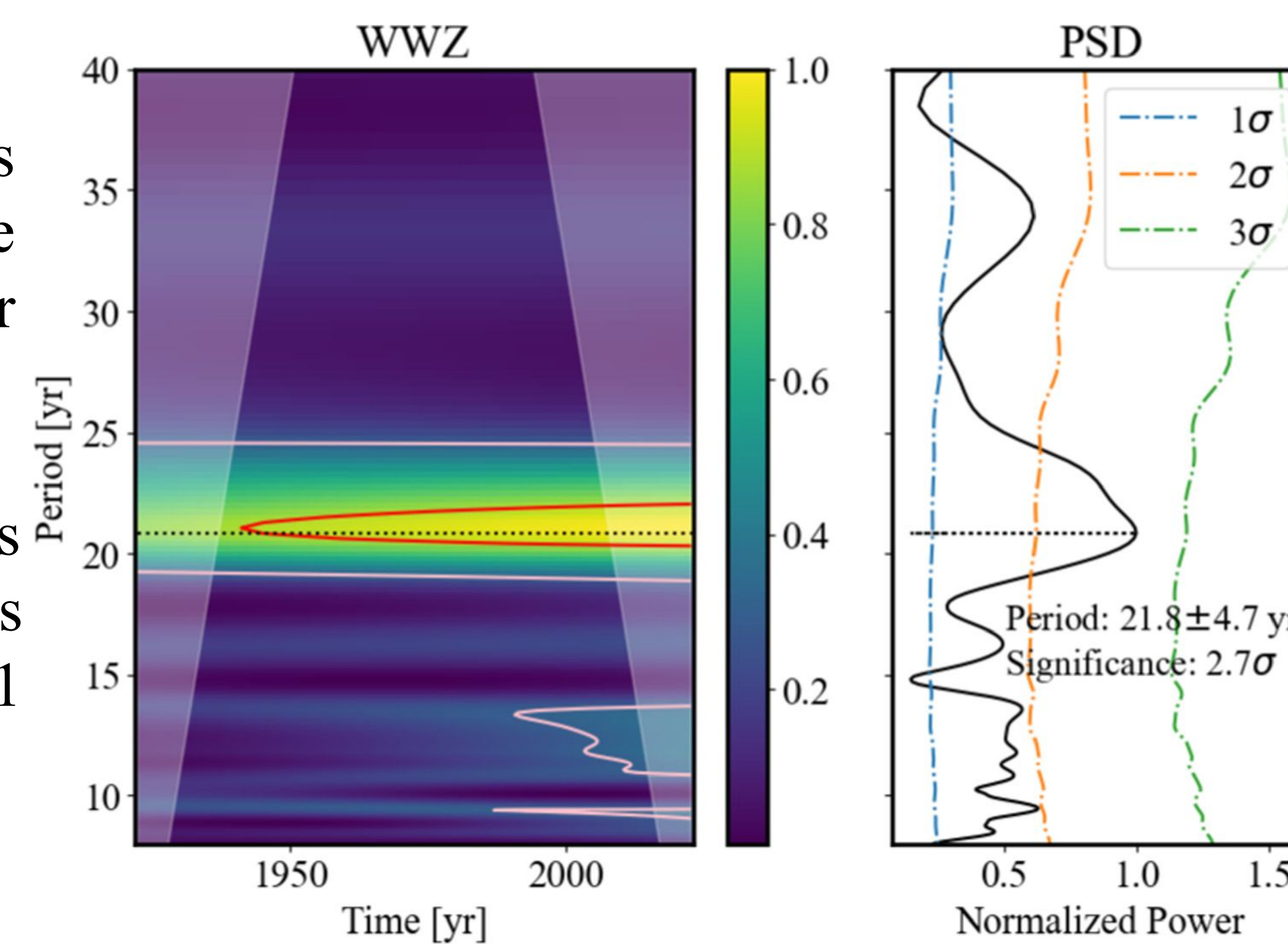


- We did not find any impact of irregular sampling in the observed period of  $\sim 22$  yr.

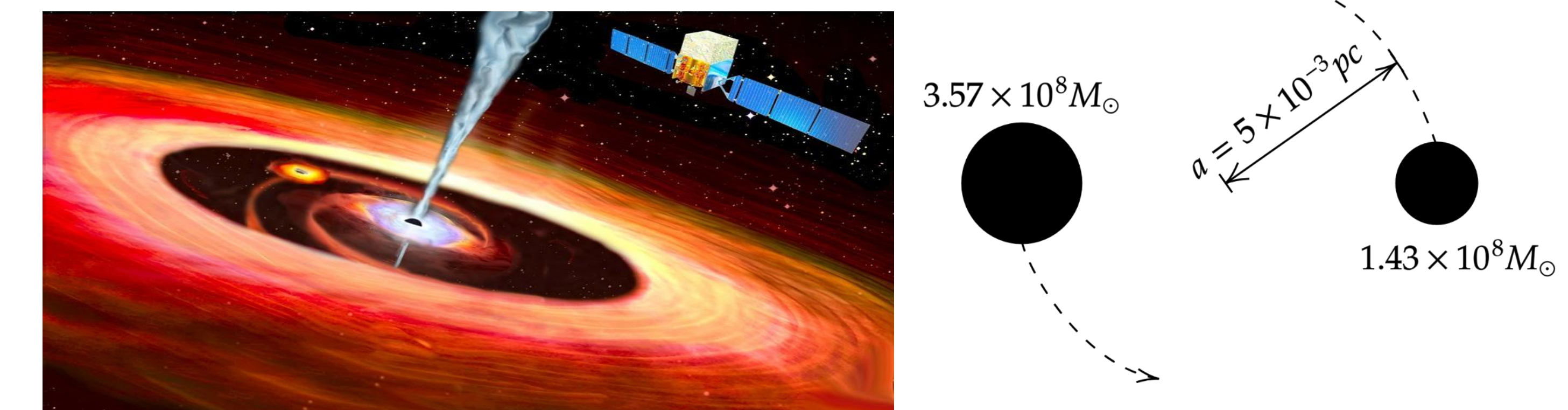
- WWZ analysis shows a stable period of  $\sim 22$  yr ( $2.7\sigma$ ).

- GLSP analysis of the LC shows a period of  $\sim 21$  yr ( $3.2\sigma$ ).

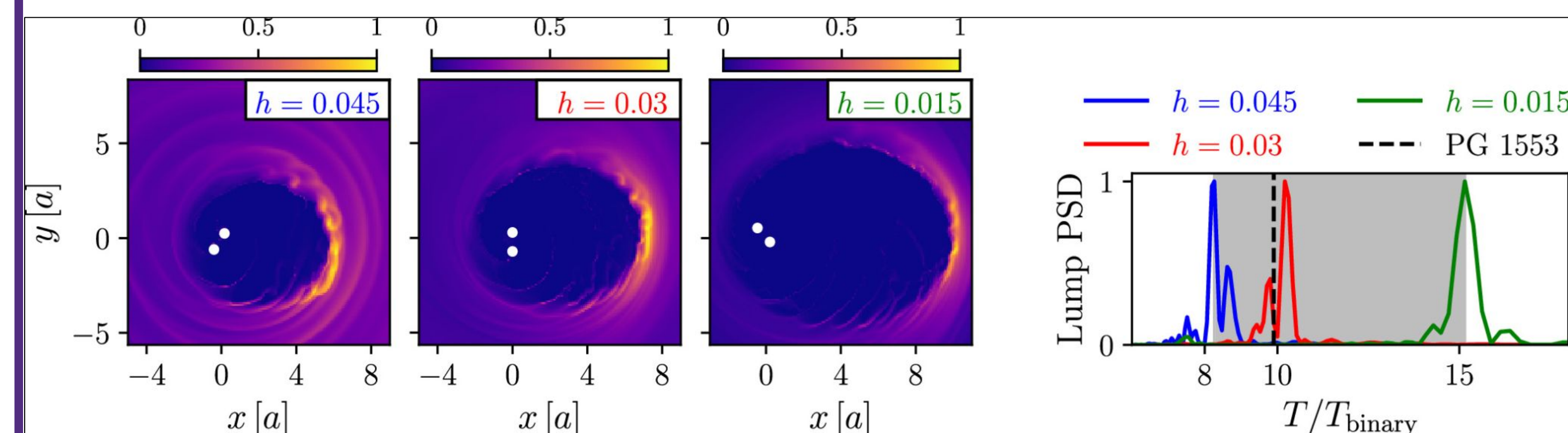
- The global significance of the 22 yr period is  $1.6\sigma$  on its own and that of the simultaneous periods of 2.2 yr and 22 yr is  $3.6\sigma$ .



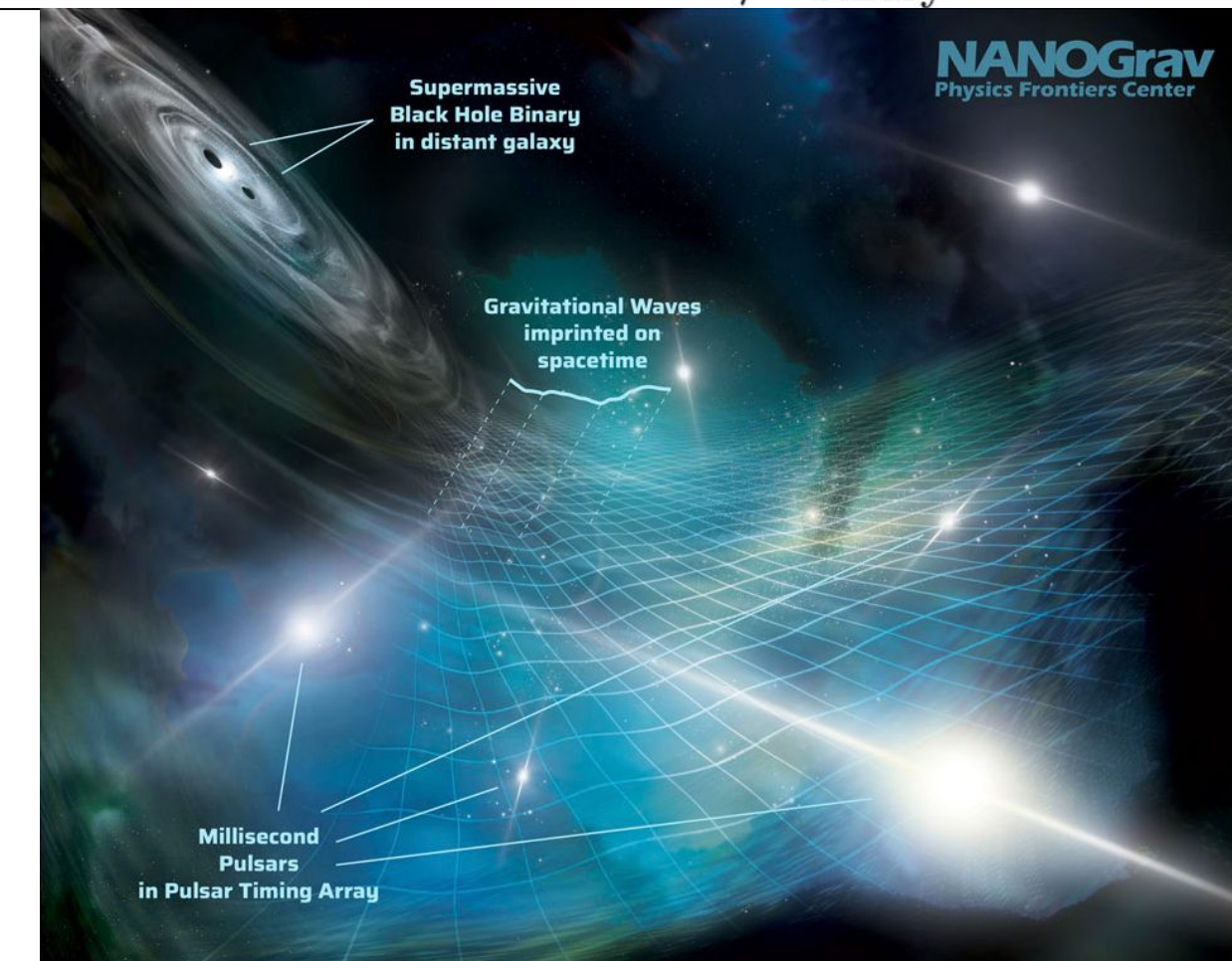
- Characterization of binary system to produce simultaneous periods:



- Lump hypothesis can produce a period of 10x the binary orbital period.



- The system generates continuous gravitational wave (GW) with frequency  $\sim 28$  nHz and a strain amplitude of  $\sim 10^{-17}$  which is two orders of magnitude lower than the current sensitivity of NANOGrav.



This work was published in the ApJ: <https://iopscience.iop.org/article/10.3847/1538-4357/ad310a> (Scan the QR code below)

## What about other blazars?

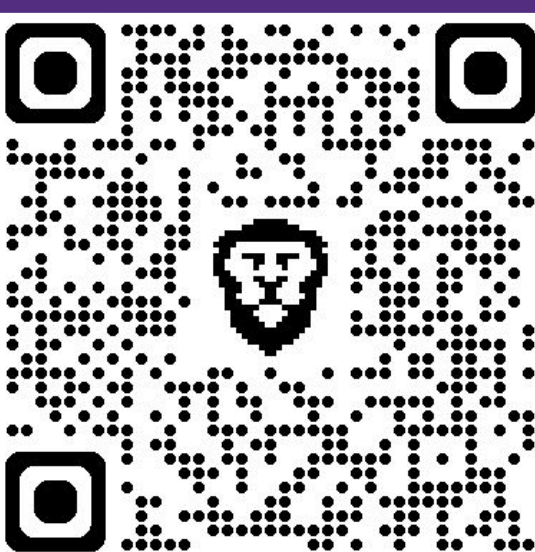
- We analyze rest of the 2FHL blazars (203) for longer-term periodicity. Preliminary results (*paper in internal review*)
- We found four blazars showing hints of decade long periodicity with lower significance than that of PG 1553+113.
- More observation is needed to access the validity of the longer-term periods in Fermi-LAT blazars.

## References

- Adhikari, S., et al. "Constraining the PG 1553+ 113 Binary Hypothesis: Interpreting Hints of a New, 22 yr Period." The Astrophysical Journal 965.2 (2024): 124.
- † Ackermann et al. (2015), LC with trend (Peñil, P., et al. Monthly Notices of the Royal Astronomical Society 527.4 (2024): 10168-10184)
- Binary artist impression (Ciprini S.), Blazar diagram (Sophia Dagnello, NRAO/AUI/NSF), Pulsar Timing Array (NANOGrav)



About me



The paper