

Maximum Likelihood Light Curve Prediction of QPO in MRK-421

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ABSTRACT

Using RXTE (Rossi X-ray Timing Explorer) and SwiftBAT (Swift Burst Alert Telescope), I modeled the X-Ray light curve of MRK-421 to investigate the quasi-periodic oscillations (QPOs). A maximum likelihood approach with a damped harmonic oscillator (DHO) model was applied to CARMA-processed light curves. Both datasets reveal periodic behavior, with SwiftBAT showing a smooth ~ 400 -day signal, and RXTE producing a staggered ~ 700 -800 day variation. Results support the presence of QPOs while highlighting instrument-dependent variability consistent with differences in sensitivity and energy range.

METHODOLOGY

Model:

- Maximum Likelihood model and DHO

Data Preparation:

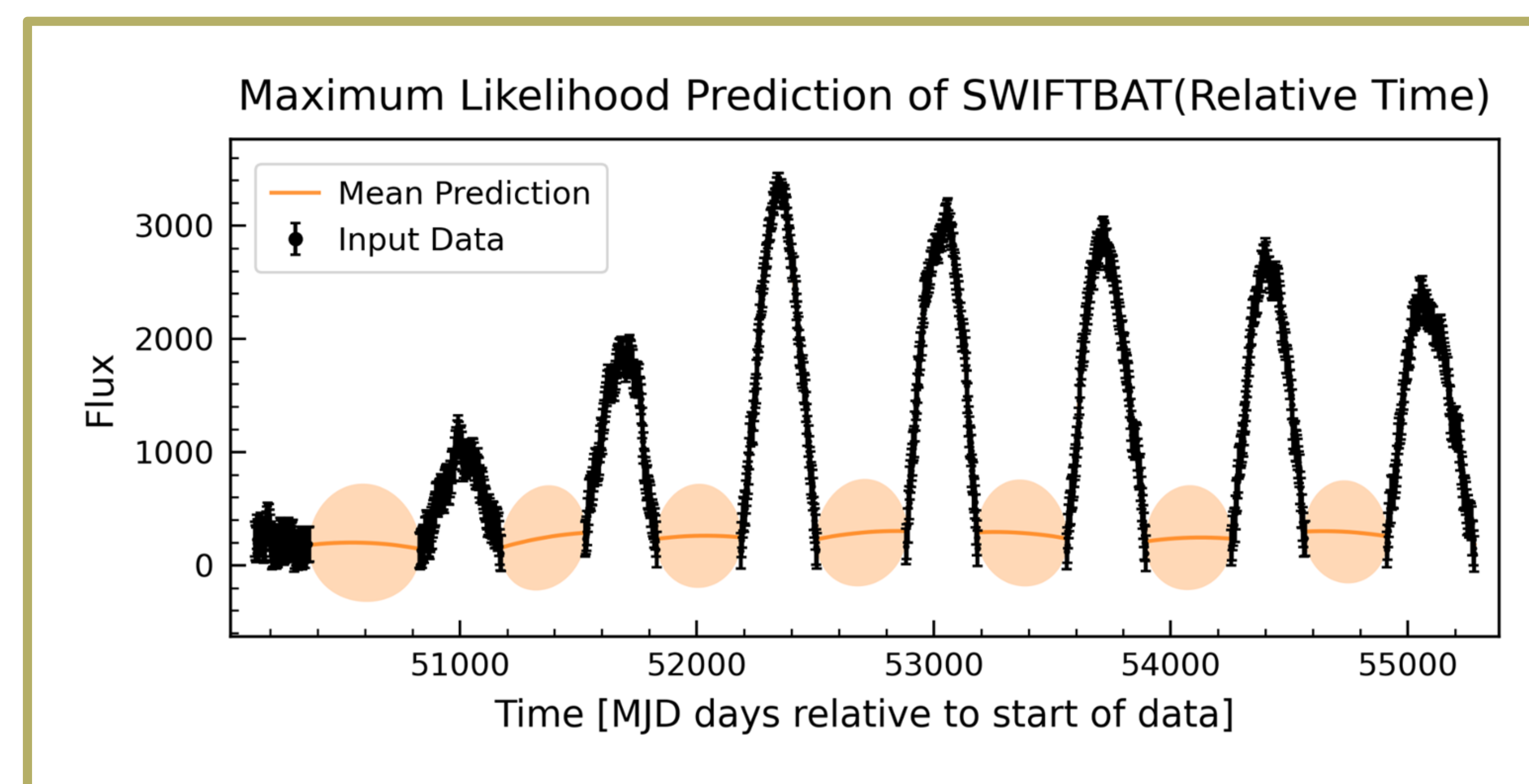
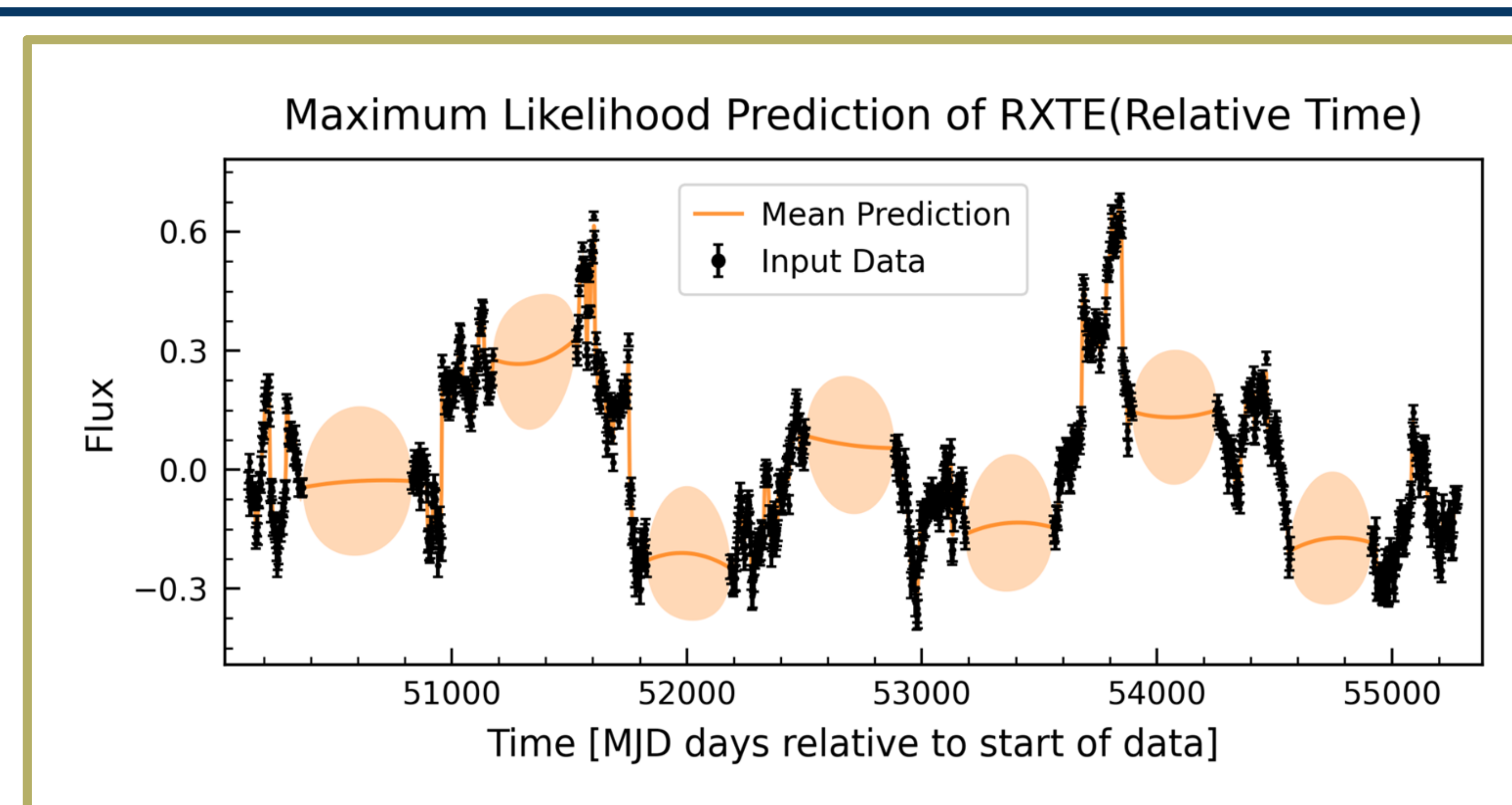
- RXTE and SwiftBAT Light Curves

Analysis:

- CARMA-based Modeling

Challenges:

- Low SNR and Irregular Sampling



RESULTS

RXTE:

- Staggered light curve
- Periodicity of about 700-800 days and max flux of 0.6
- Prediction closely matches observed and hypothesized prediction

Comparison:

- Differences likely due to the observational bandwidth of the instruments.
- Small variations occur between runs because the prediction model updates as new predictive data is generated.

SwiftBAT:

- Smooth, sinusoidal light curve
- Period of about 400 MJD, and max flux of ~ 1800 (1200 average)
- Consistent with previous predictions

CONCLUSION

- QPO periodicity of ~ 400 days confirmed
- RXTE produces more light curve variability than SwiftBAT
- Differences are due to instrument sensitivity
- Model has effectively captured observational behavior

REFERENCES

- Smith, E. et. al., 2023, APJ, 950, 174
- Smith, E. et. al., 2020, APJ, 902, 65
- Yu, W et. al., 2022, Astrophysics Source Code Library
- Yu, W et. al., 2022, APJ, 936, 132

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