# Quasi-Periodic Oscillations: A New Approach to Determine Spin of Black Hole

**Priti Finavia**

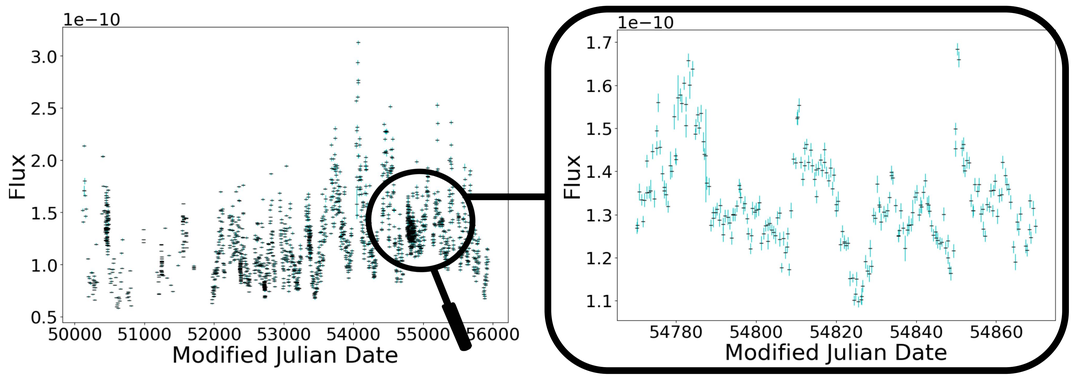
**Faculty Advisor(s): Dr. Eric Perlman, Dr. Evan Smith, Dept. of APSS, Florida Institute of Technology**

## ABSTRACT

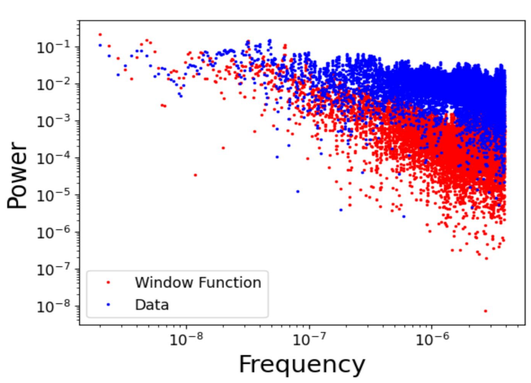
We propose a new method to measure supermassive black hole (SMBH) spin using Active Galactic Nuclei (AGN) quasi-periodic oscillations (QPOs). We report the discovery of ~242 day and ~33.2 day QPOs found using archival 3C 273 data observed by RXTE. Using the recent mass estimate of 3C 273, it is possible to match the radius in the Lense-Thirring model to the Keplerian radius to measure the spin of the SMBH.

## INTRODUCTION

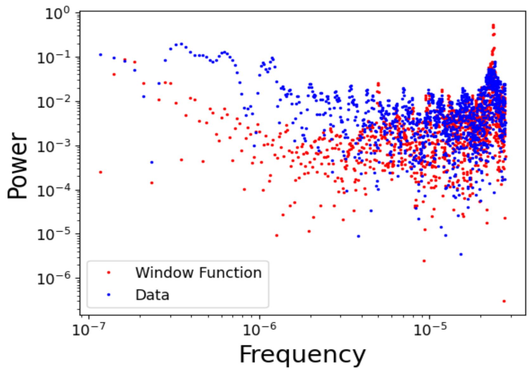
- QPOs are an important observable in accretion disks and have been and have been studied extensively in X-ray binaries.
- QPOs should be present in AGN if galactic black holes and SMBH are governed by the common set of physical processes.
- A possible explanation for QPOs includes Keplerian orbital motion of matter in the disk, general relativistic effects, spin of the central compact object, or beat frequencies between two of the previous mechanisms [1][2].
- The relativistic precession disk model suggests that the upper QPO frequency is Keplerian orbital frequency while the lower QPO frequency is the Lense-Thirring precession (LTP) period.
- LTP is a relativistic correction to the precession of the gyroscope near SMBH [3].
- The object of interest is 3C 273, a flat-spectrum radio quasar.



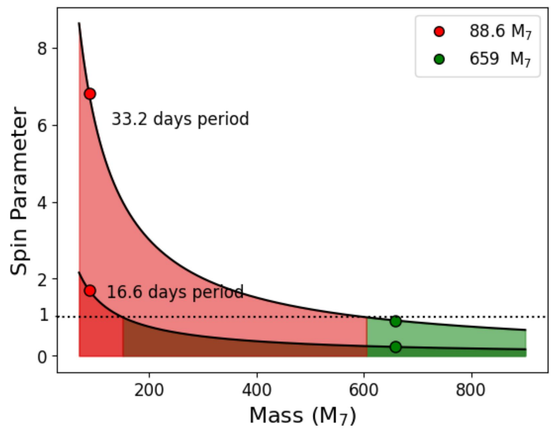

The RXTE 3C 273 light curve of all observations from 1996 to 2011 as well as the high-density monitoring from 2008 to 2009 .




Power spectrum of all observations show ~242 days QPO.




Power spectrum of high-density monitoring show ~33.2 days QPO.




Permitted values of the spin parameter for 33.2 day and 16.6 day QPOs.

## ACKNOWLEDGMENTS

This work utilized light curves provided by the University of California, San Diego, Center for Astrophysics and Space Sciences, X-ray Group (R.E. Rothschild, A.G. Markowitz, E.S. Rivers, and B.A. McKim), obtained at http://cass.ucsd.edu/rxteagn/

## DATA ANALYSIS

- The data was used from RXTE archive [4] and passed through Python program to get light curves and power spectrum using Lomb-Scargle Periodogram.
- The regular interval was about 3 pointings a week. It is about 1906 observations spanning 5811 days.

## DISCUSSION

- We report the discovery of ~242 day and ~33.2 day QPOs.
- The ~242 day QPO appears to have been present over the entire 1996-2011 RXTE lifespan, while the ~33.2 day QPO was detected only during a denser cluster of observations in 2008-2009.
- Using both QPOs and $M_7$ = 659, the spin parameter of the SMBH was determined to be 0.92 ± 0.19 [5].
- With $M_7$ = 88.6, the spin parameter of the SMBH was determined to be 6.8, which is physically impossible as it should remain within the boundary of -1 to 1.

## REFERENCES

**[1]** Ingram, A. R., & Motta, S. E. 2019, NewAR, 85, 101524.

**[2]** van der Klis, M., 2000 ARA&A, 38, 717.

**[3]** Lense, J., & Thirring, H. 1918, Physikalische Zeitschrift, 19.

**[4]** Rivers, E., Markowitz, A., & Rothschild, R., 2013, *ApJ*, 772 , 114.

**[5]** Paltani, S., & T¨urler, M. 2005, A&A, 435, 811.