# HIGH FREQUENCY QPOs IN THE TRANSIENT SOURCE XTE 1701-462

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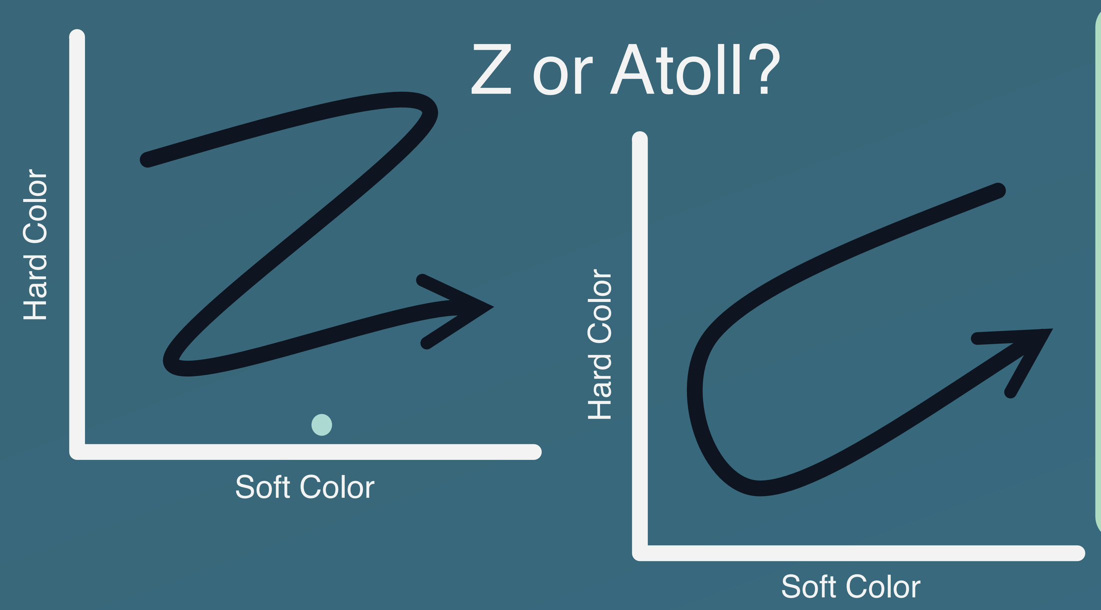
Understanding the mechanism that produces the quasi-periodic oscillations (QPOs) that we observe in the light curves of neutron star X-ray binaries (NSXBs) could help us shed a light onto the mysterious nature of these sources. QPOs are believed to be produced in the innermost part of NSXBs and, using timing analysis tools, we are trying to disentangle the hidden information that they carry.

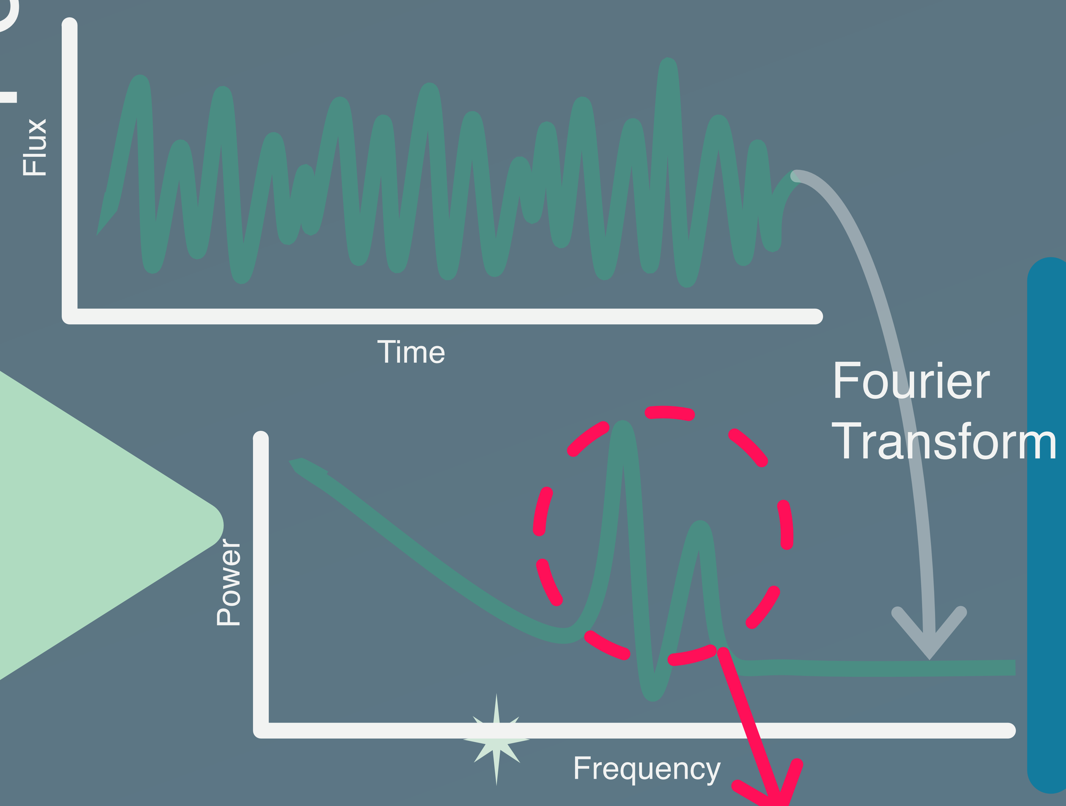
## XTE 1701-462

This NSXB gives us an unique perspective when analysing the differences between Atoll and Z sources. Reported[1] as the best example of the rare case of a source that has shown Atoll-like and Z-like behaviour during its 2006-2007 outburst, this source offers a remarkable opportunity to study the properties of kHz QPOs and time lags during different states of the same source.




## Power Spectra

The power spectral density function (PSD) allows us to study the underlying probability distribution of a stochastic phenomenon like the variability of NSXBs light curves.
In simple words, the PSD represents the light curve of a NSXB - a signal in the time domain - as a signal in the frequency domain [2].



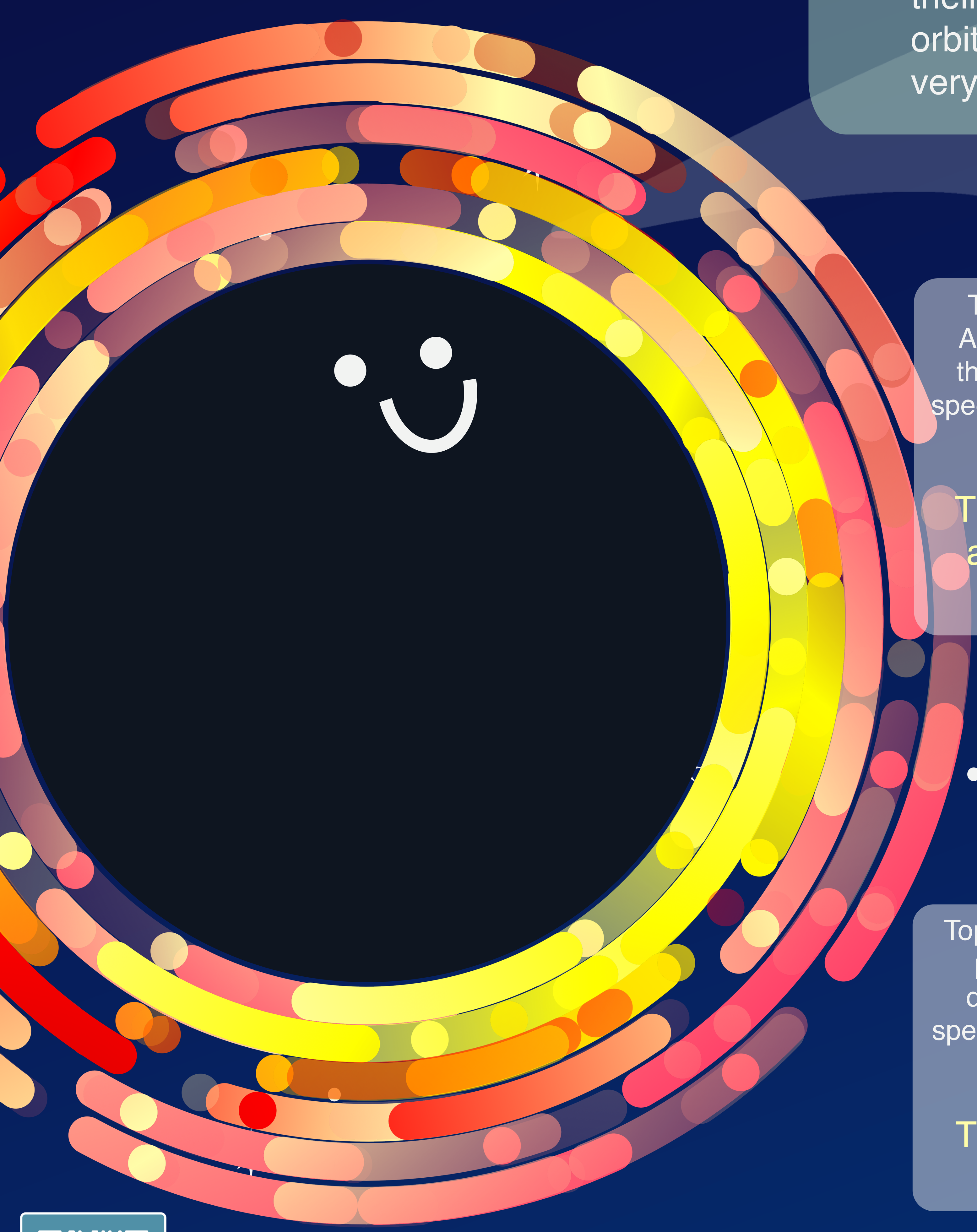

High frequency QPOs (or kHz QPOs) have been of great interest in the study of the variability of NSXBs. This type of QPOs are believed to probe the innermost parts of NSXBs because of their similarities in frequency with the orbital movement of matter in regions very close to the neutron star [3].

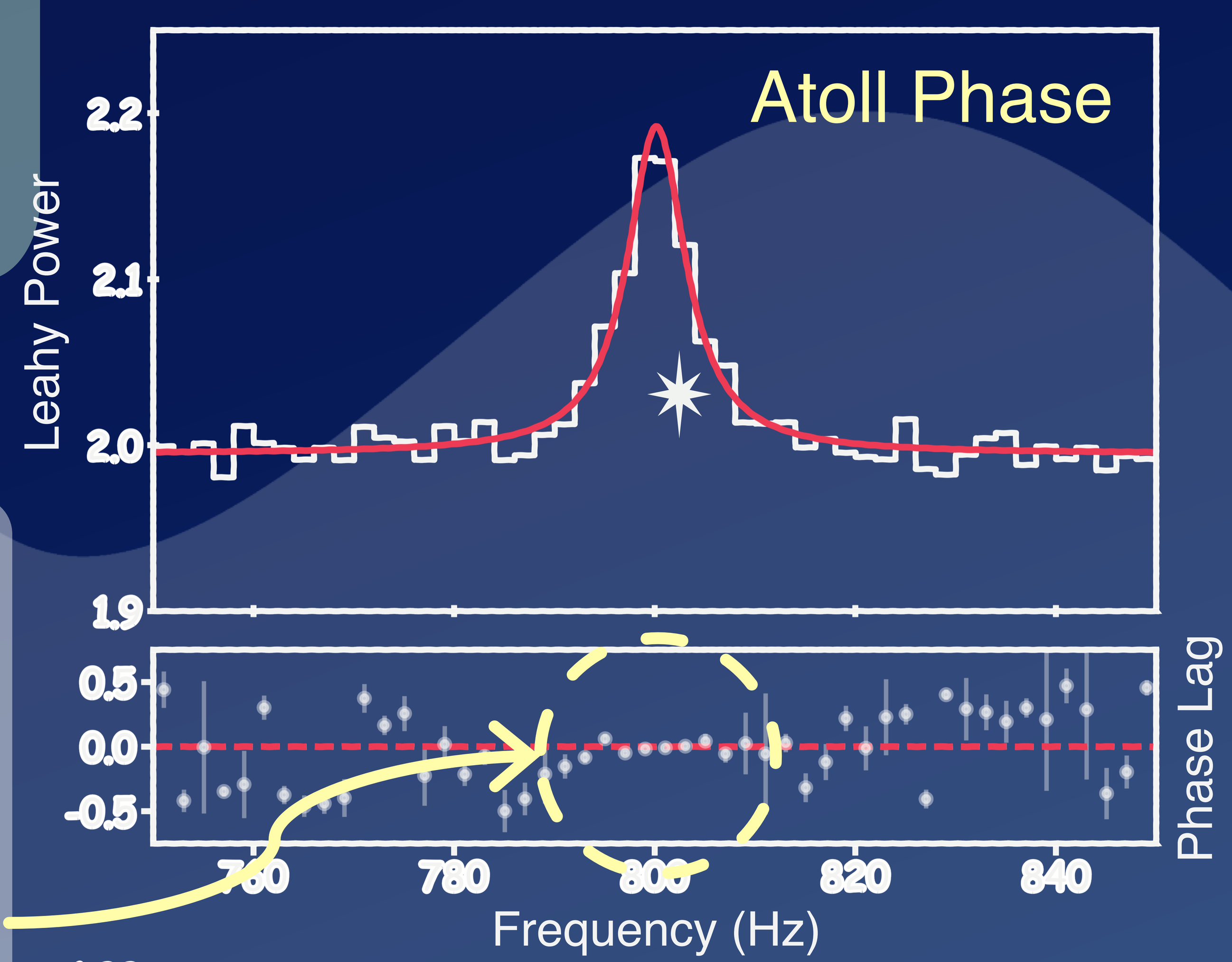
## Lag Spectra

Lags measure the Fourier frequency-dependent time delay between two correlated time series [4]. Soft lags mean that the soft photons (lower energies) are arriving after the hard photons (higher energies) to the detector. Hard lags represent the opposite.

PRELIMINARY RESULTS
During the Atoll phase of XTE 1701-462 we can only see one kHz QPO, and at its frequency the lags are negative (soft lags).
However, during the Z phase (where 2 kHz QPOs are visible: upper and lower), the signal is not coherent enough to be able to measure a lag.

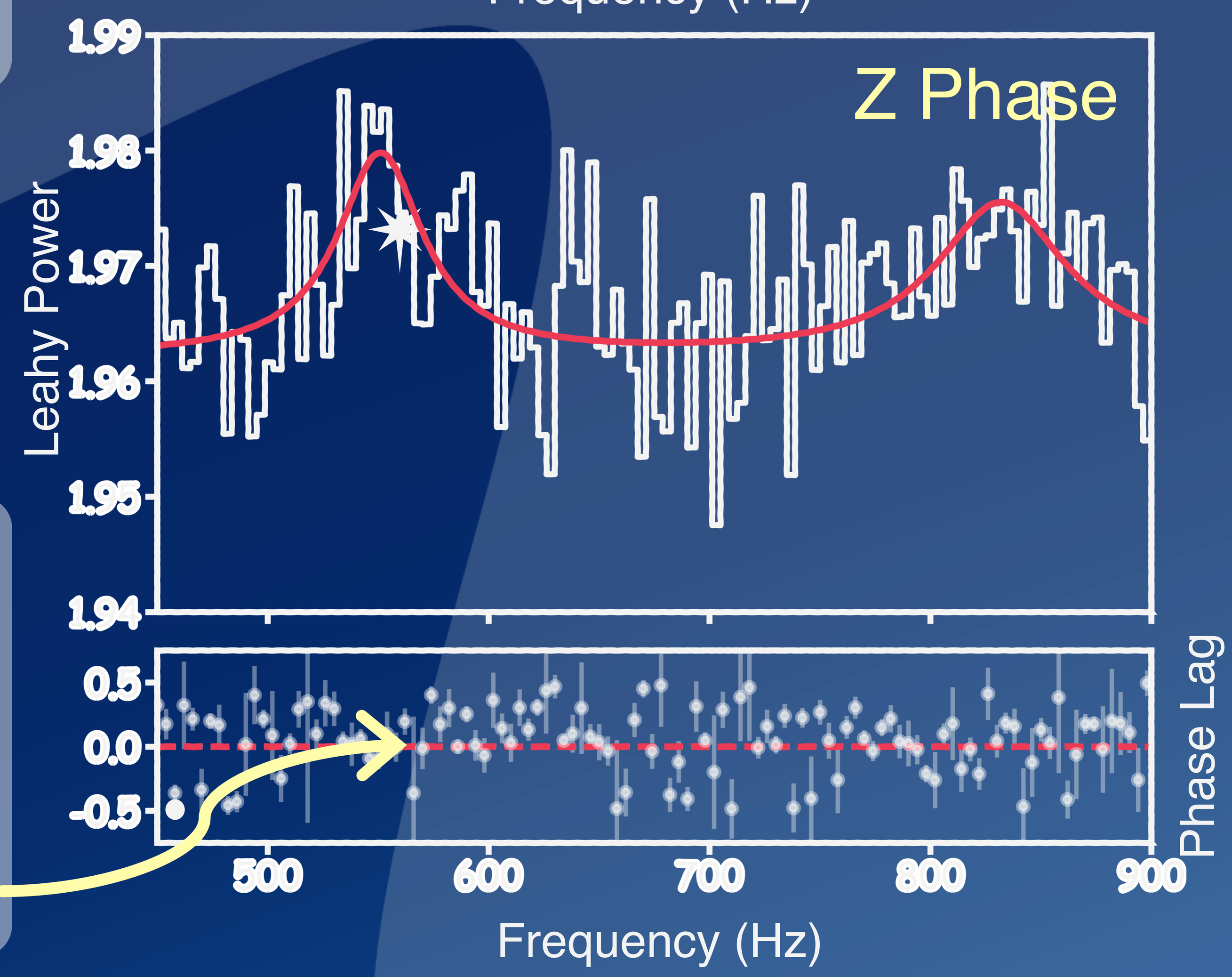
We now need to know why. What is changing between both phases? Why are the lags different? How does this depend on energy or QPO frequency?






Top: Power spectrum of all shifted-and-added Atoll phase observations combined, centred in the detected kHz QPO frequency. Bottom: Lag spectrum of the same observations, with the soft band as reference band.

The lag at the frequency of the QPO appears to be slightly negative (soft lag)




Top: Power spectrum of all shifted-and-added Z phase observations combined, centred in the detected kHz QPOs frequencies. Bottom: Lag spectrum of the same observations, with the soft band as reference band.

The lag at the frequency of the QPO is not significant enough.

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References:
[1] Homan, J. et al. (2007), *Astrophys. J.*, 656(1):420–430.
[2] Uttley, P. et al. (2014), *Astron. Astrophys. Rev.*, 22(1):72.
[3] Strohmayer, T. E. et al. (1996), *Astrophys. J.*, 469(1):L9–L12.
[4] Nowak, M. A. et al. (1999), *Astrophys. J.*, 510(2):874–891.