Lense-Thirring Precession around neutron stars with known spin

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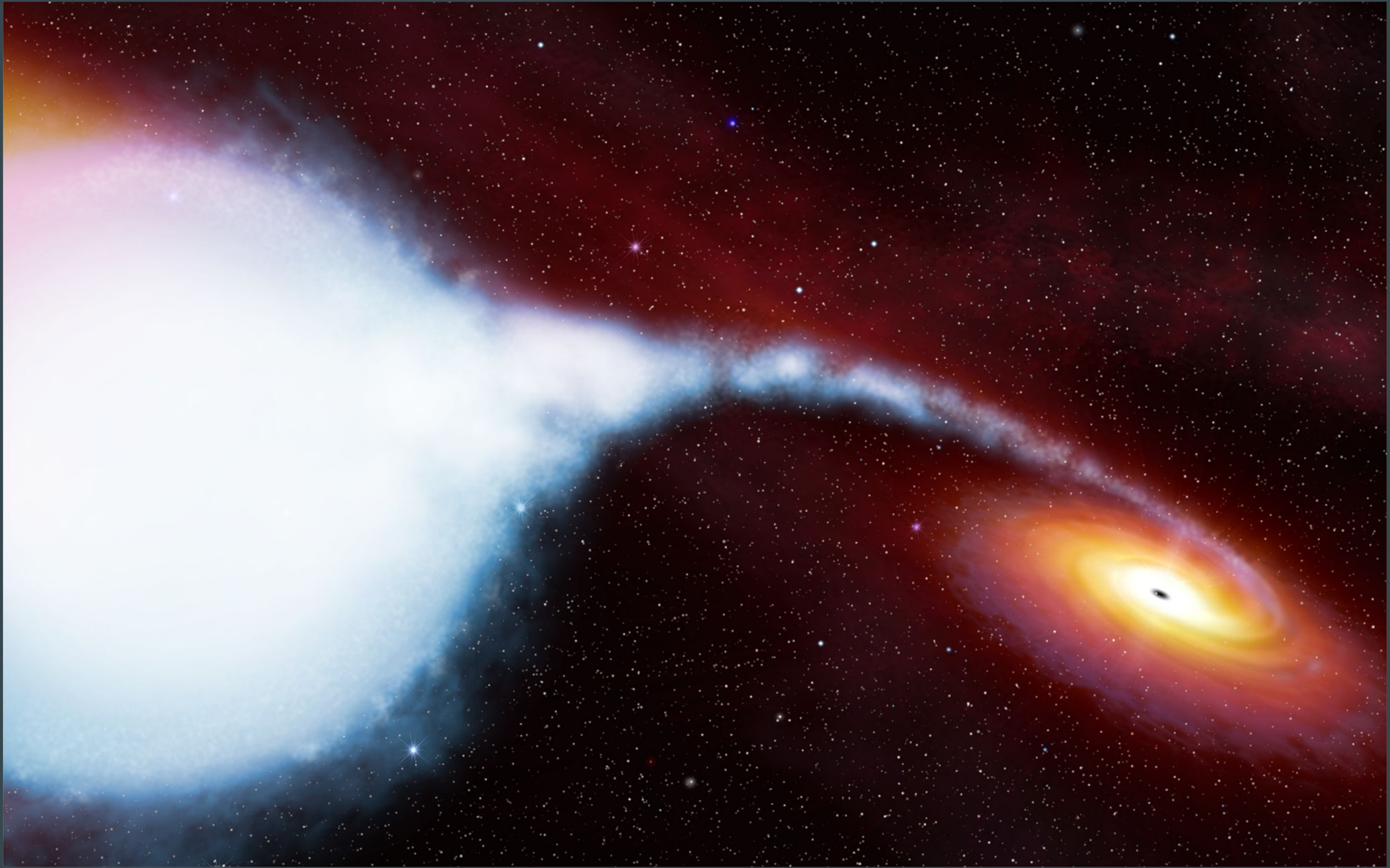
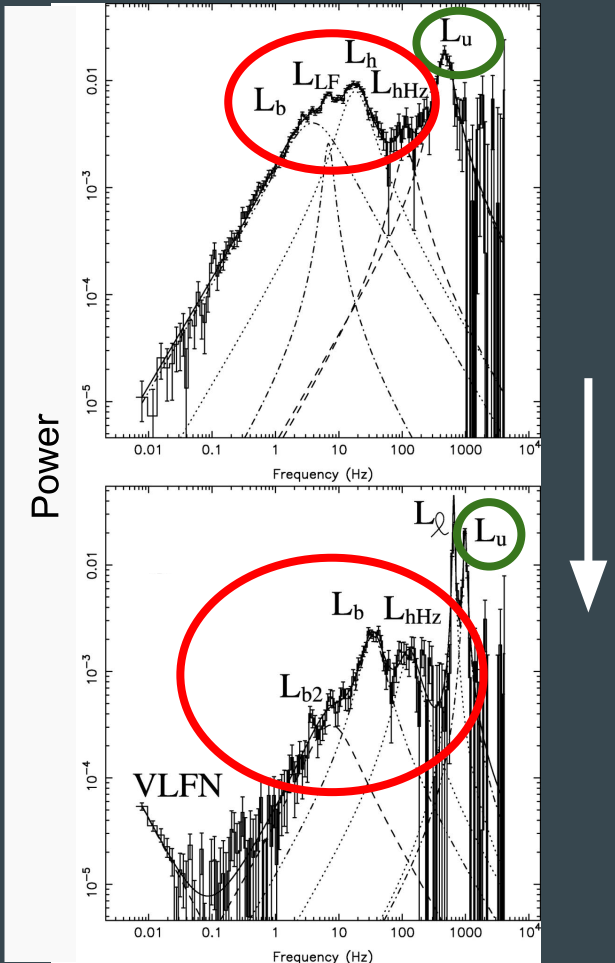
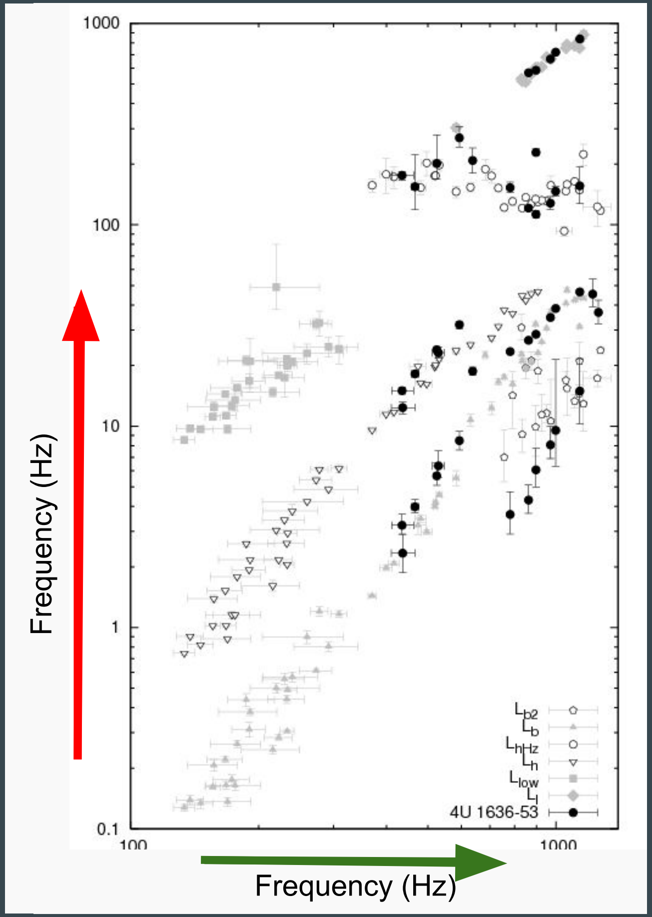


kHz QPO frequency correlates with LF QPO





Altamirano et al. (2008)

Lense-Thirring precession might explain correlations

RPM: Frequency depends on spin

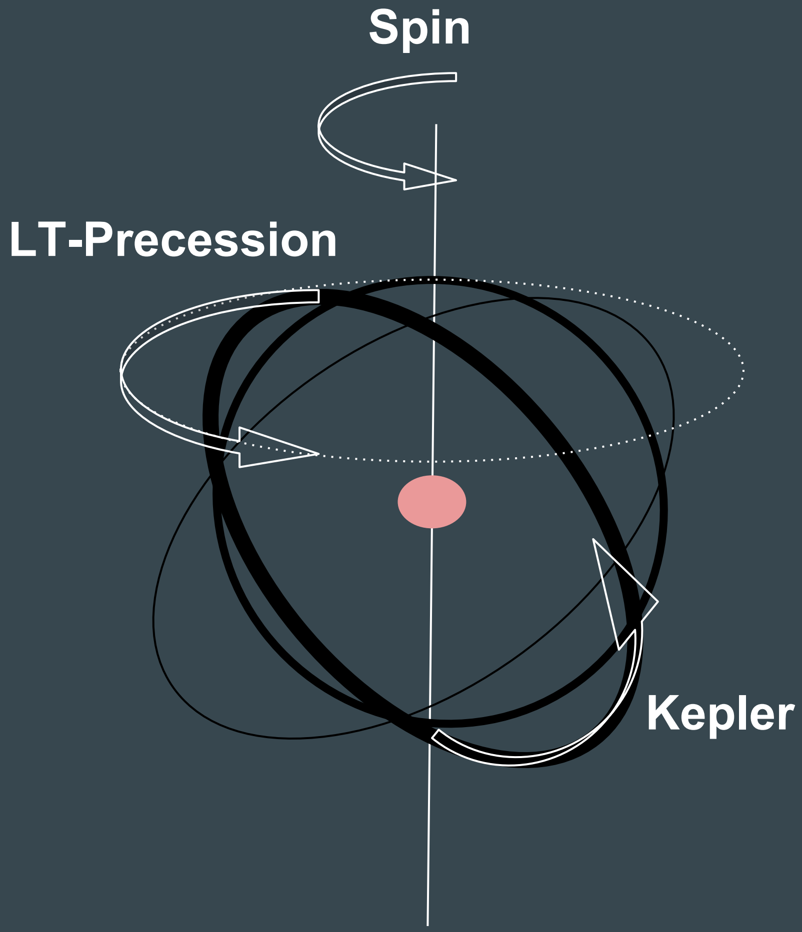
$$\nu_{LT} = 4.4 \times 10^{-8} \frac{I}{M} \nu_{Spin} \nu_{Kepler}^2$$

Stella & Vietri (1998)

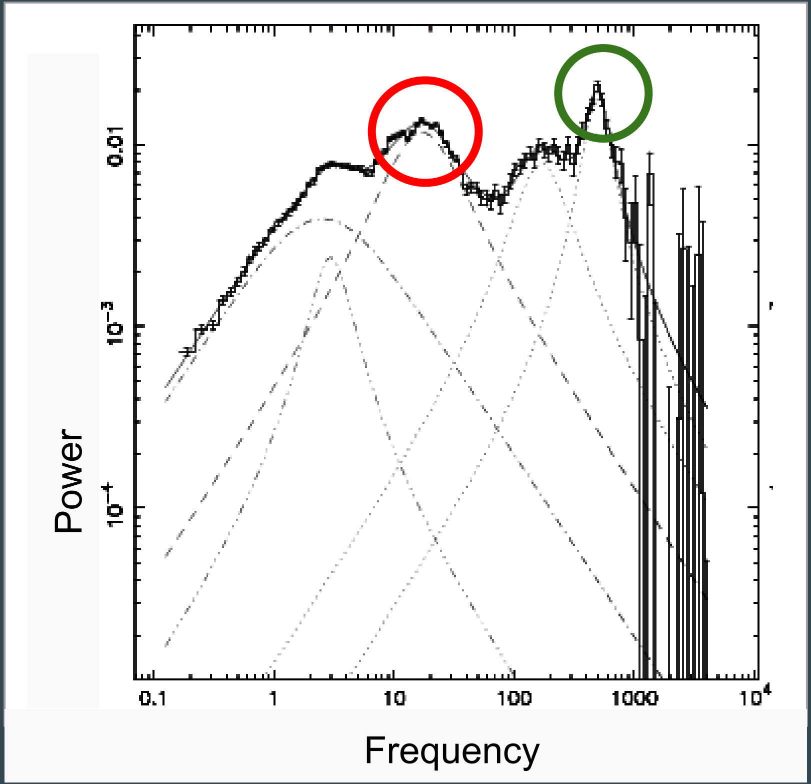
EOS limit range of I/M

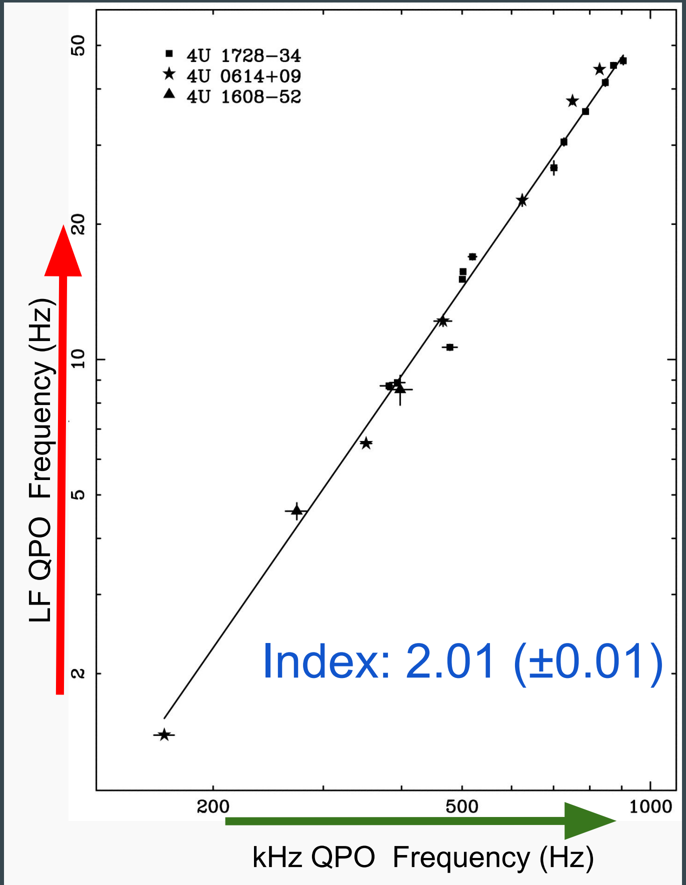
$$0.5 < \frac{I}{M} < 2$$

Friedman et al. (1986)



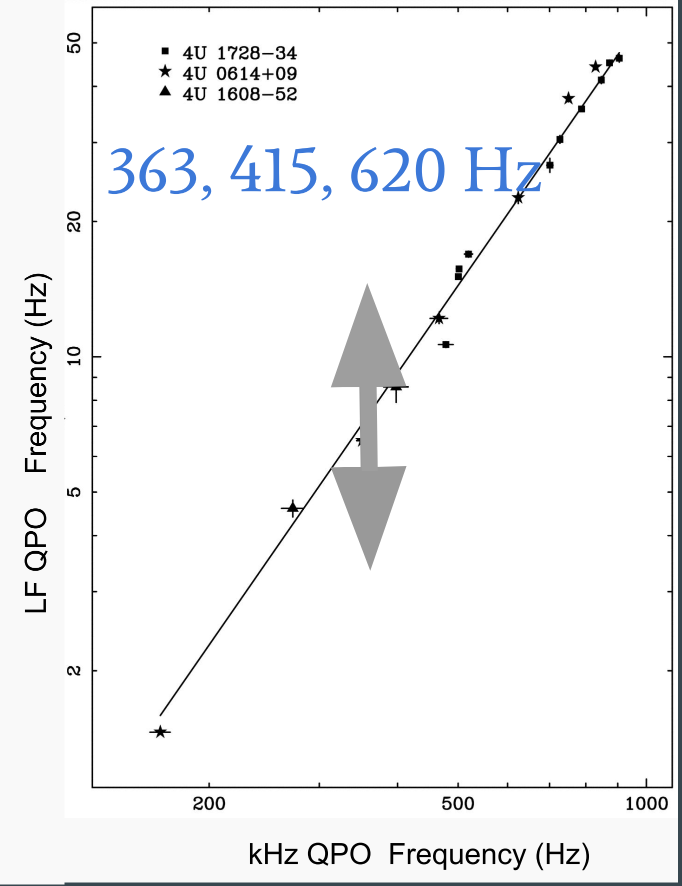
Striking correspondence to theory found





Van Straaten et al. (2003)

But the NS spin frequencies differ



Difference in spin would introduce scatter

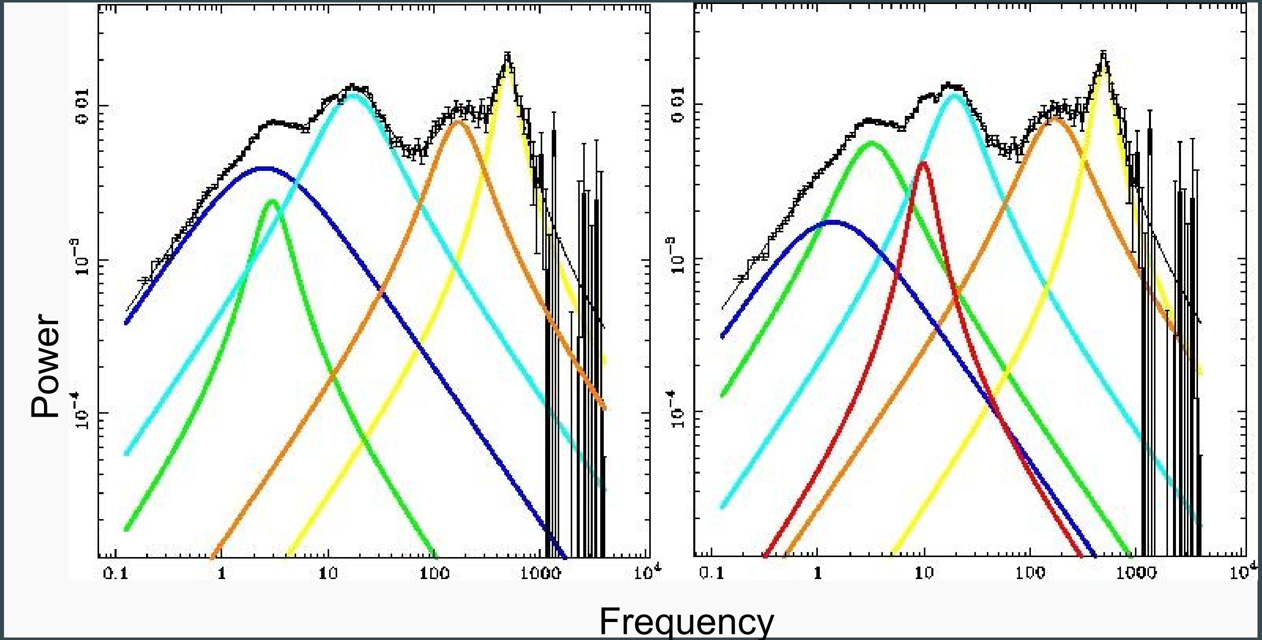
Van Straaten et al. (2003)

We present the results of 13 ‘known spin’ sources

Burst oscillation sources
kHz & LF QPOs

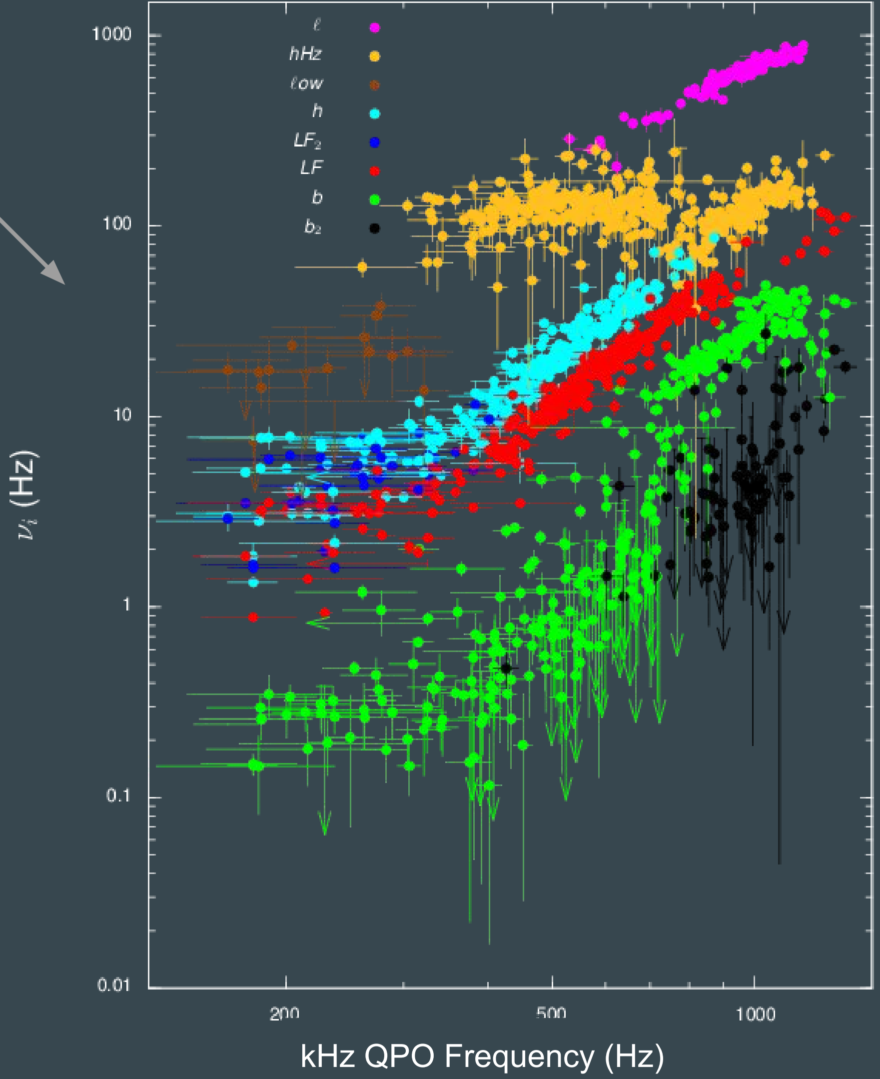
RXTE data

We limit averaging
of power spectra



Result: detailed 'frequency fingerprint'

All sources

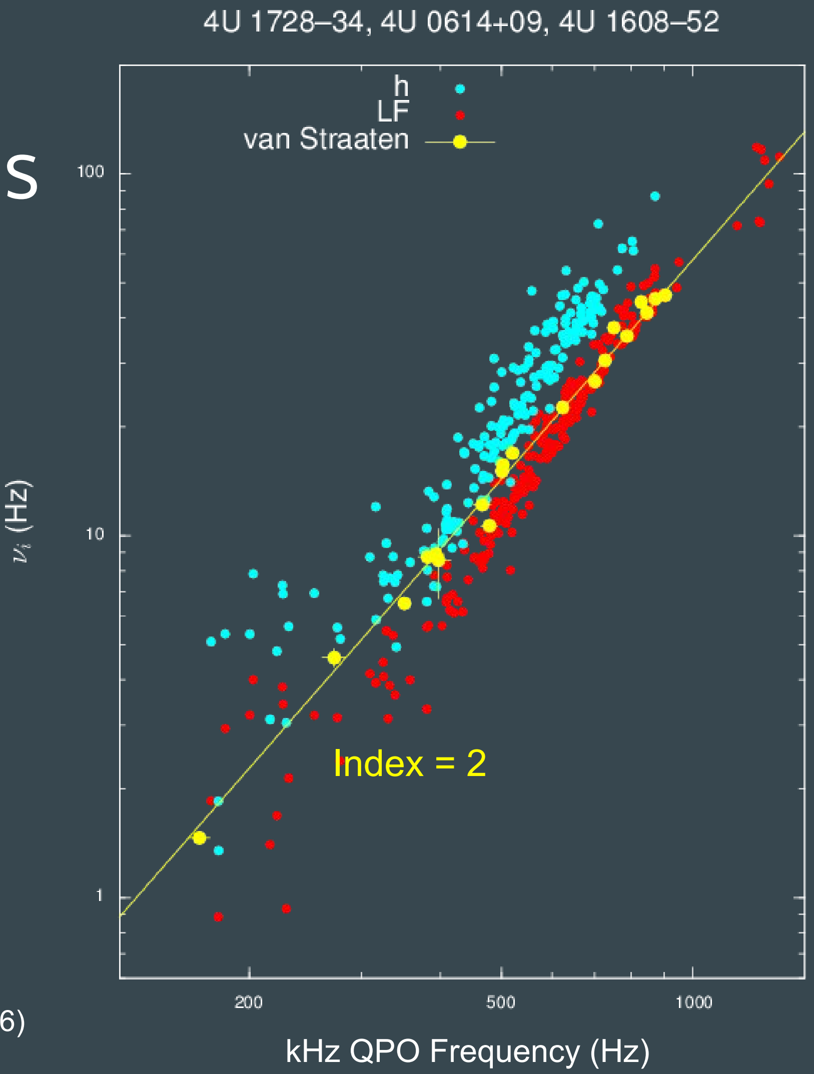


van Doesburgh & van der Klis (2016)

We find two low frequency QPOs

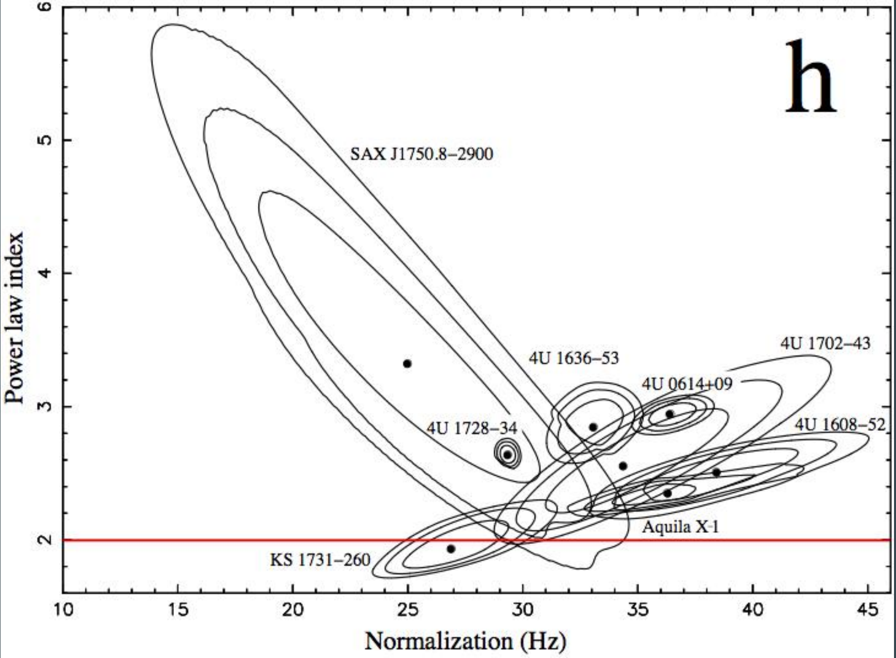
Correlations have indices >2

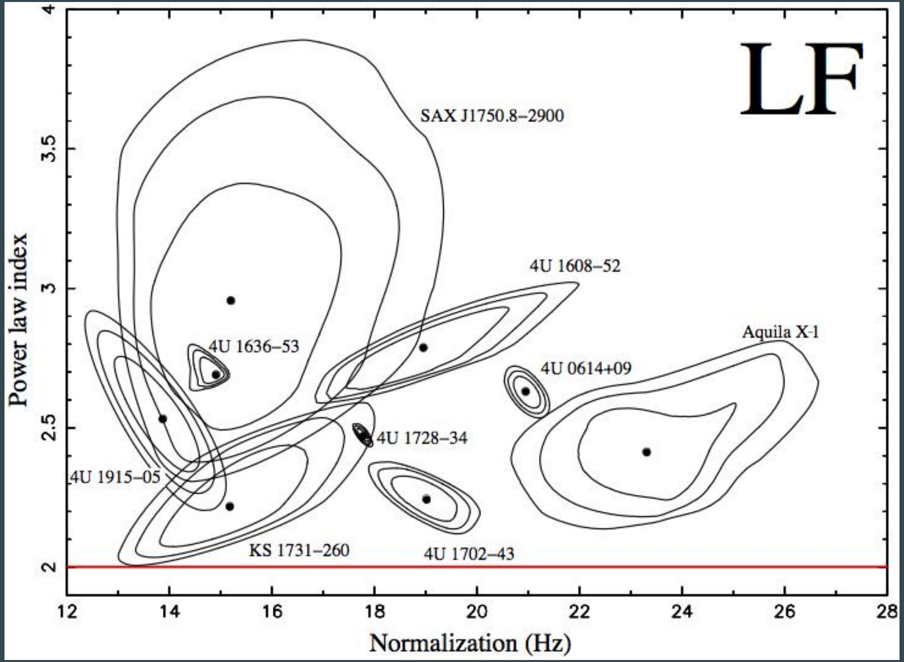
Blending of narrow features distorts correlations



van Doesburgh & van der Klis (2016)

Correlations differ between sources





van Doesburgh & van der Klis (2016)

RPM in original form incompatible with Data

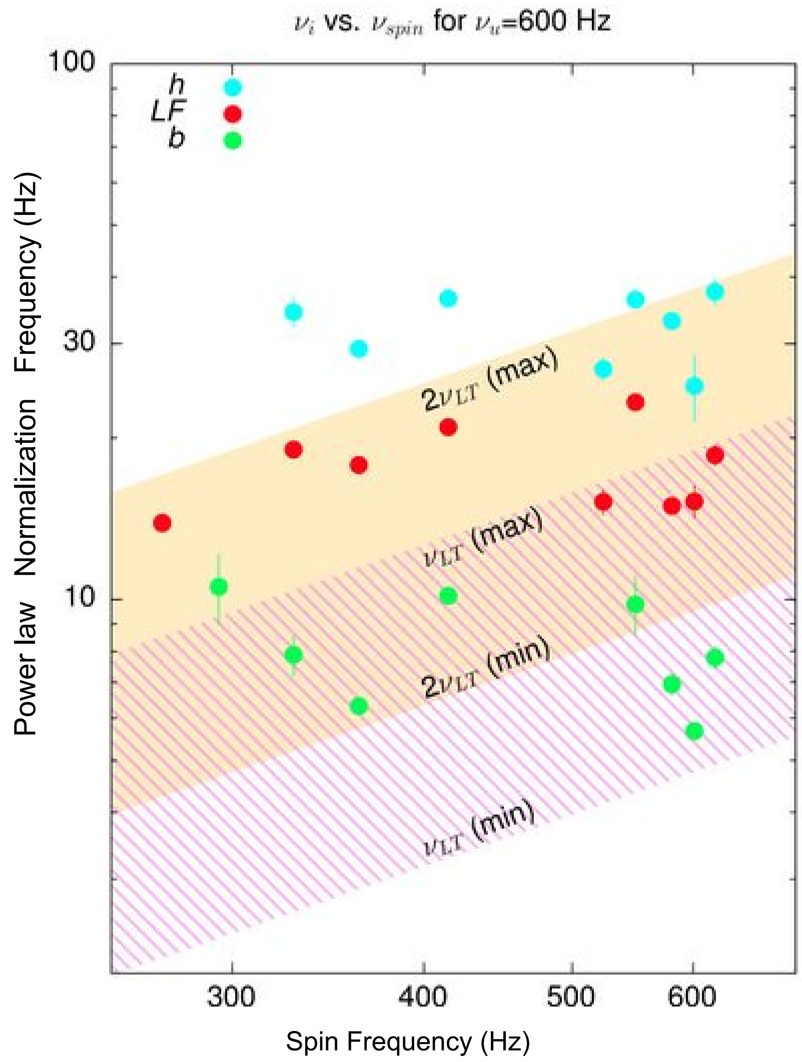
Three main issues:

- Frequencies are too high for realistic EOS
Radiation pressure (Miller, 1999)

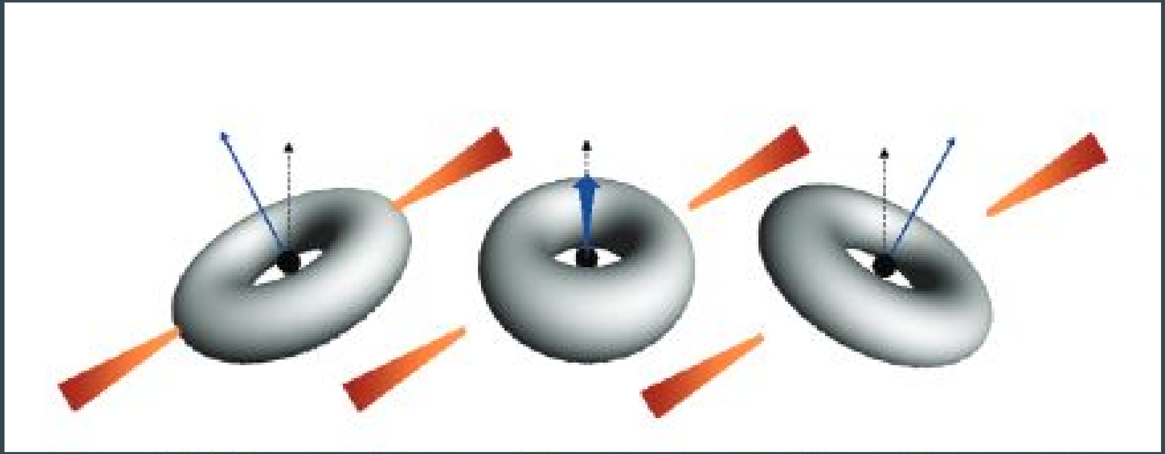
- Indices are >2

- No spin dependence
Retrograde classical (index 2.3), magnetic precession (index 4)?

For a weakly magnetized NS, LT-precession dominates with a power law index <2
(Shirakawa, 2002)



A precessing torus might explain high indices



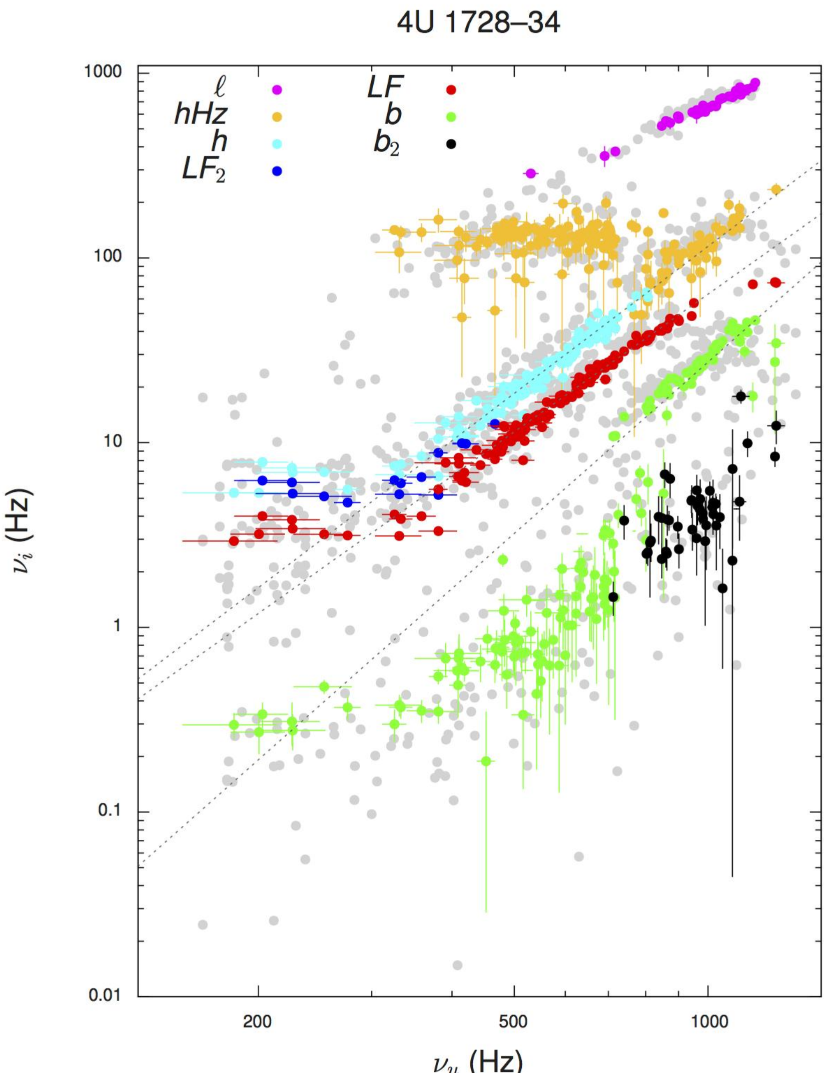
Ingram et al. (2009)

More detail with e-XTP

QPOs suffer from blending

Change in index as kHz QPO increases

Van Doesburgh & van der Klis (2016)



Summary

- We measured frequency correlations in 13 NS-LMXBs with known spin

- QPOs suffer from blending/smearing

- Best-fit power laws are incompatible with RPM (index, frequencies,spin)

- Frame dragging is likely only one of the torques contributing to precession

With e-XTP:

Measuring frequency correlations for more sources & in more detail