NEUTRON STAR ASTEROSEISMOLOGY WITH MAGNETAR BURSTS

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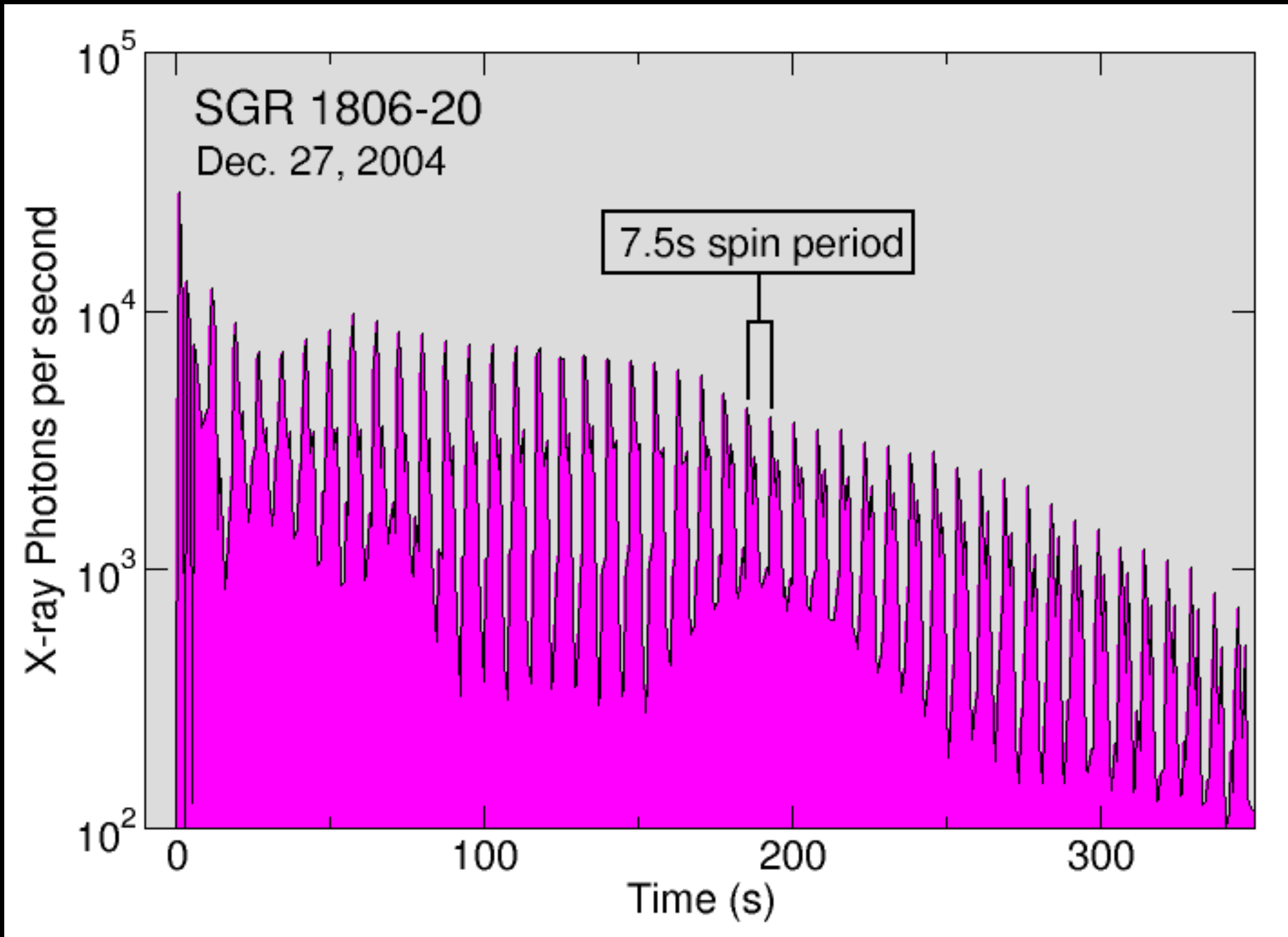
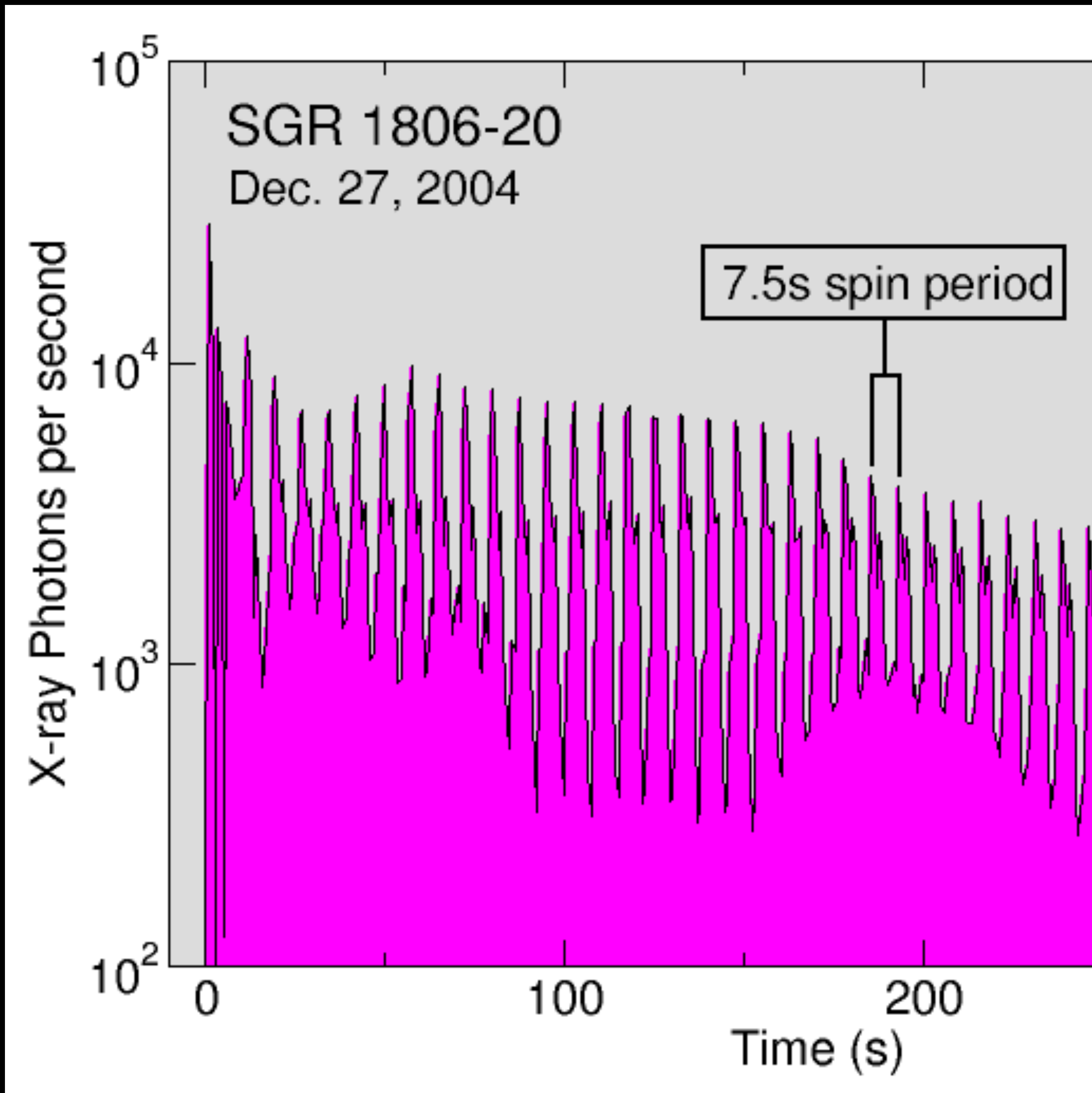
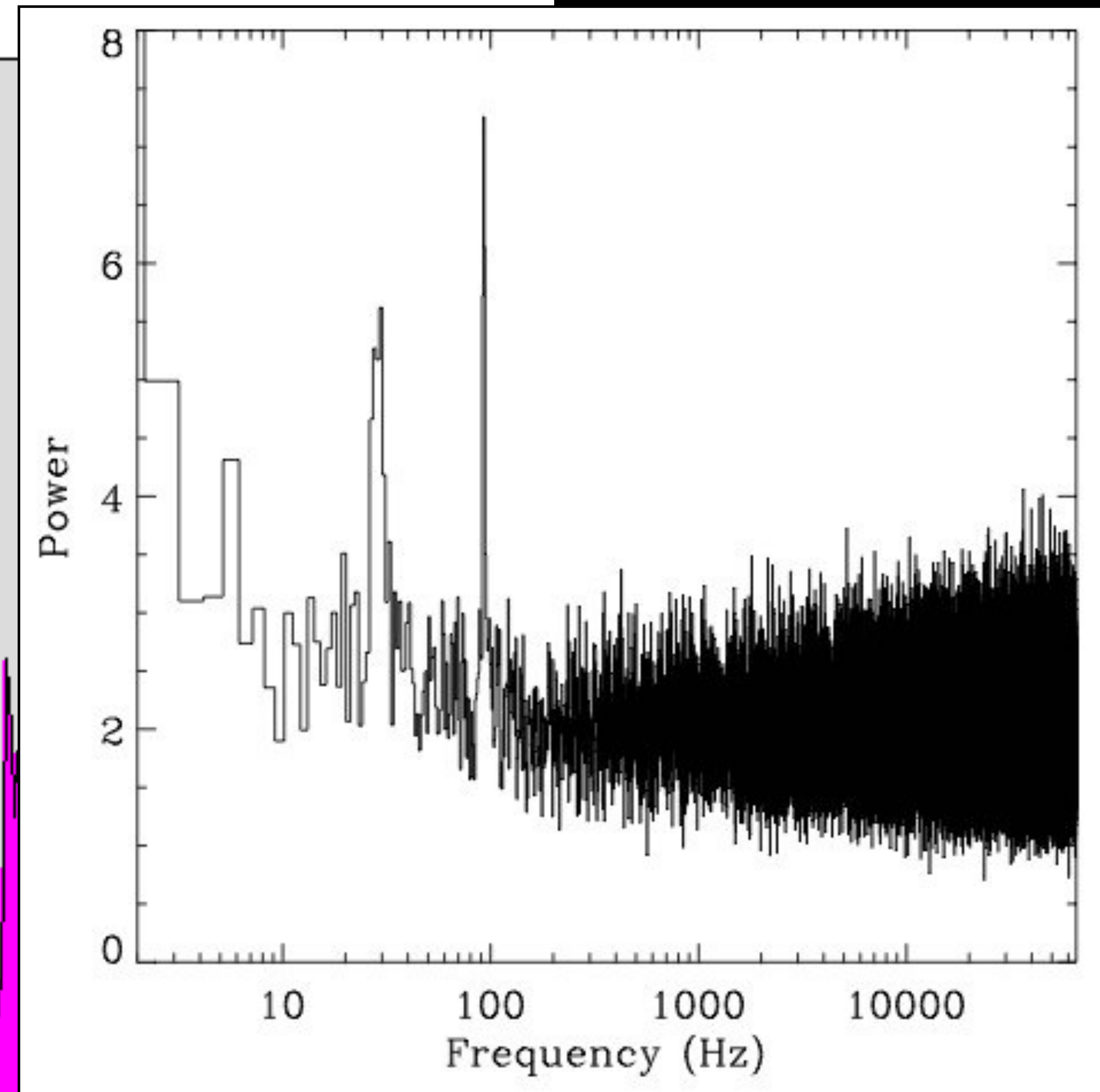
GIANT FLARE ASTEROSEISMOLOGY



Giant flare QPOs: Israel et al. 2005, Strohmayer & Watts 2005,6, Watts & Strohmayer 2006

GIANT FLARE ASTEROSEISMOLOGY

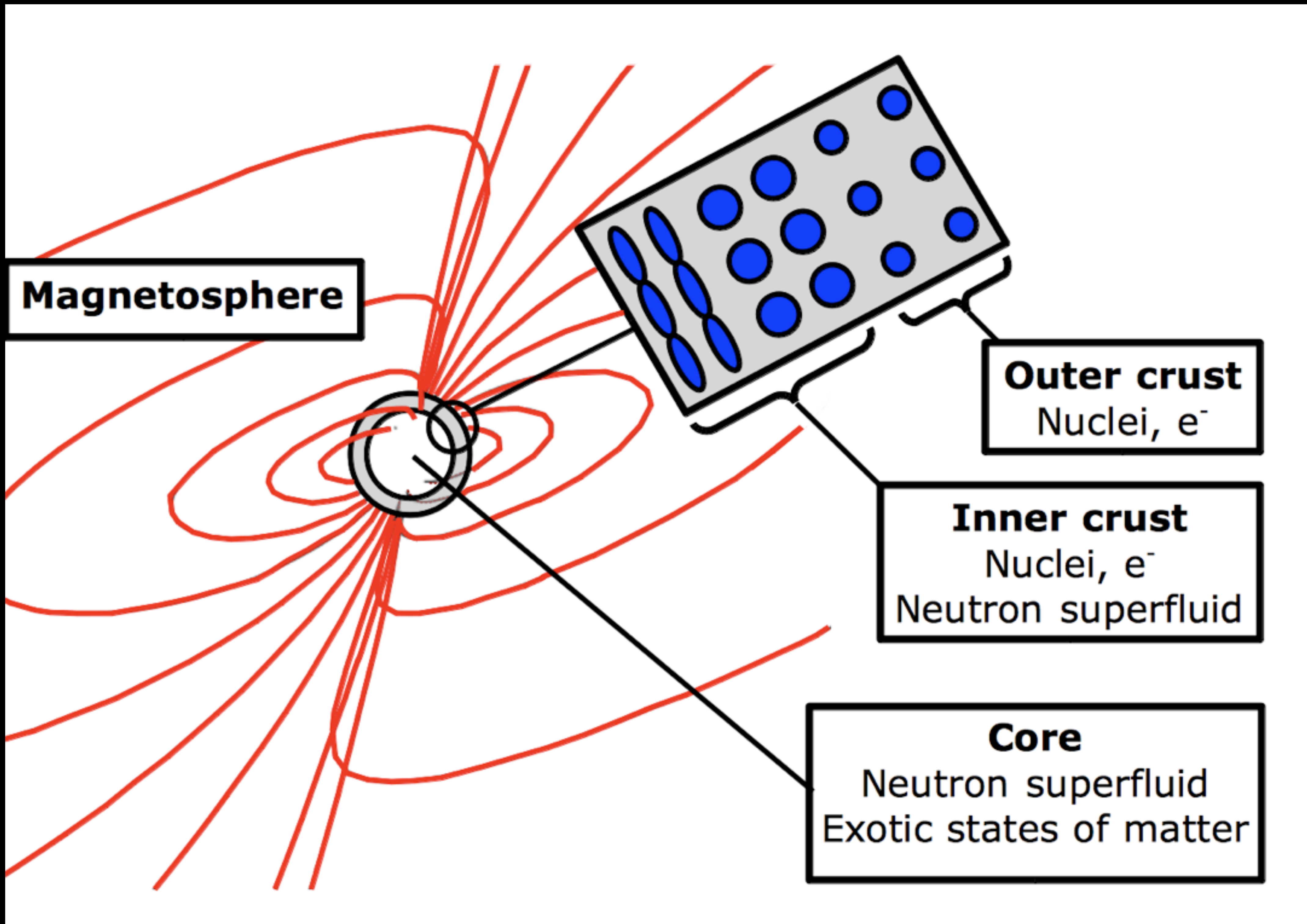




18-1800 Hz Quasi-Periodic Oscillations (QPOs)

Giant flare QPOs: Israel et al. 2005, Strohmayer & Watts 2005,6, Watts & Strohmayer 2006

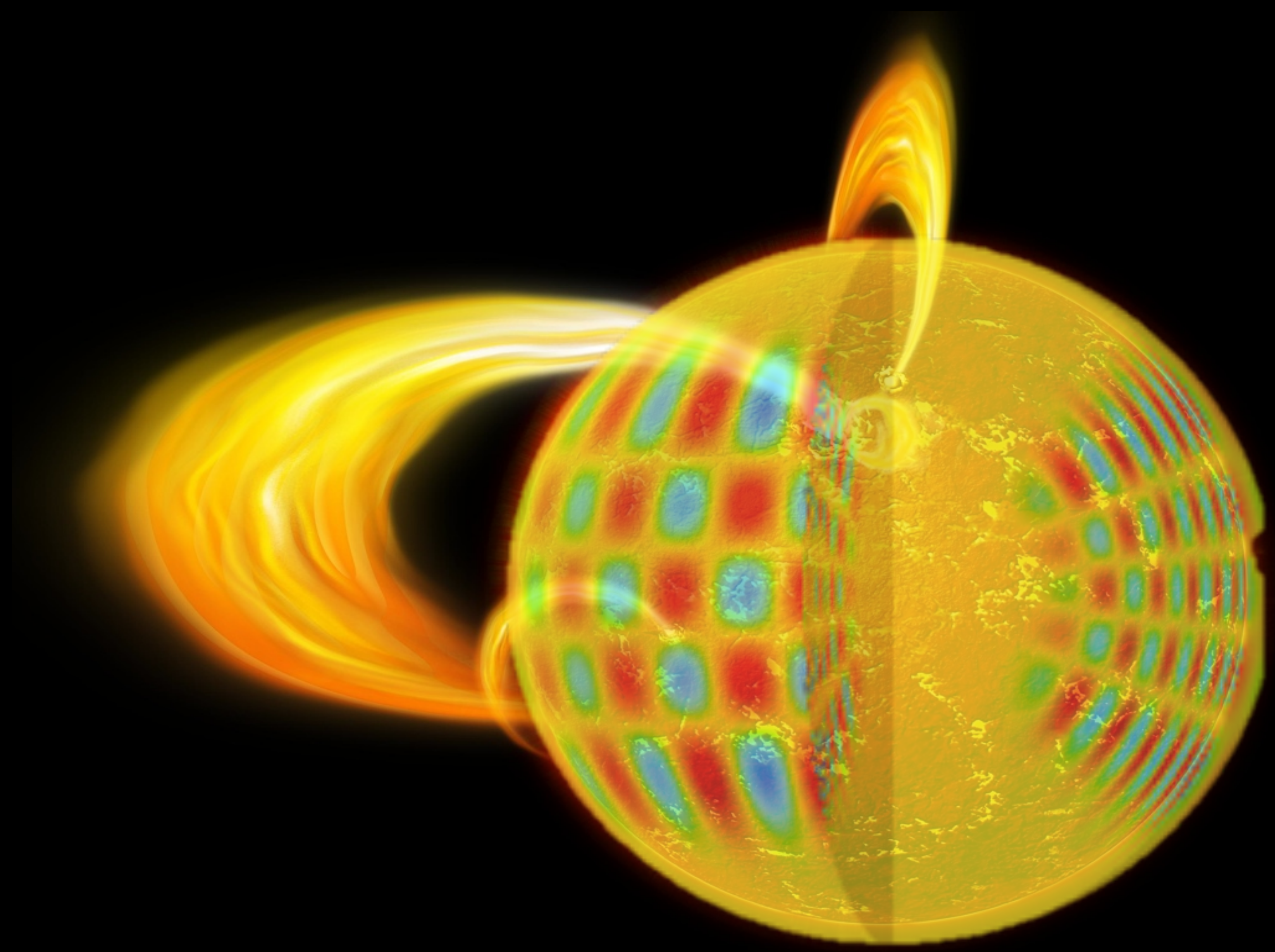
NEUTRON STAR COMPONENTS



Watts 2013

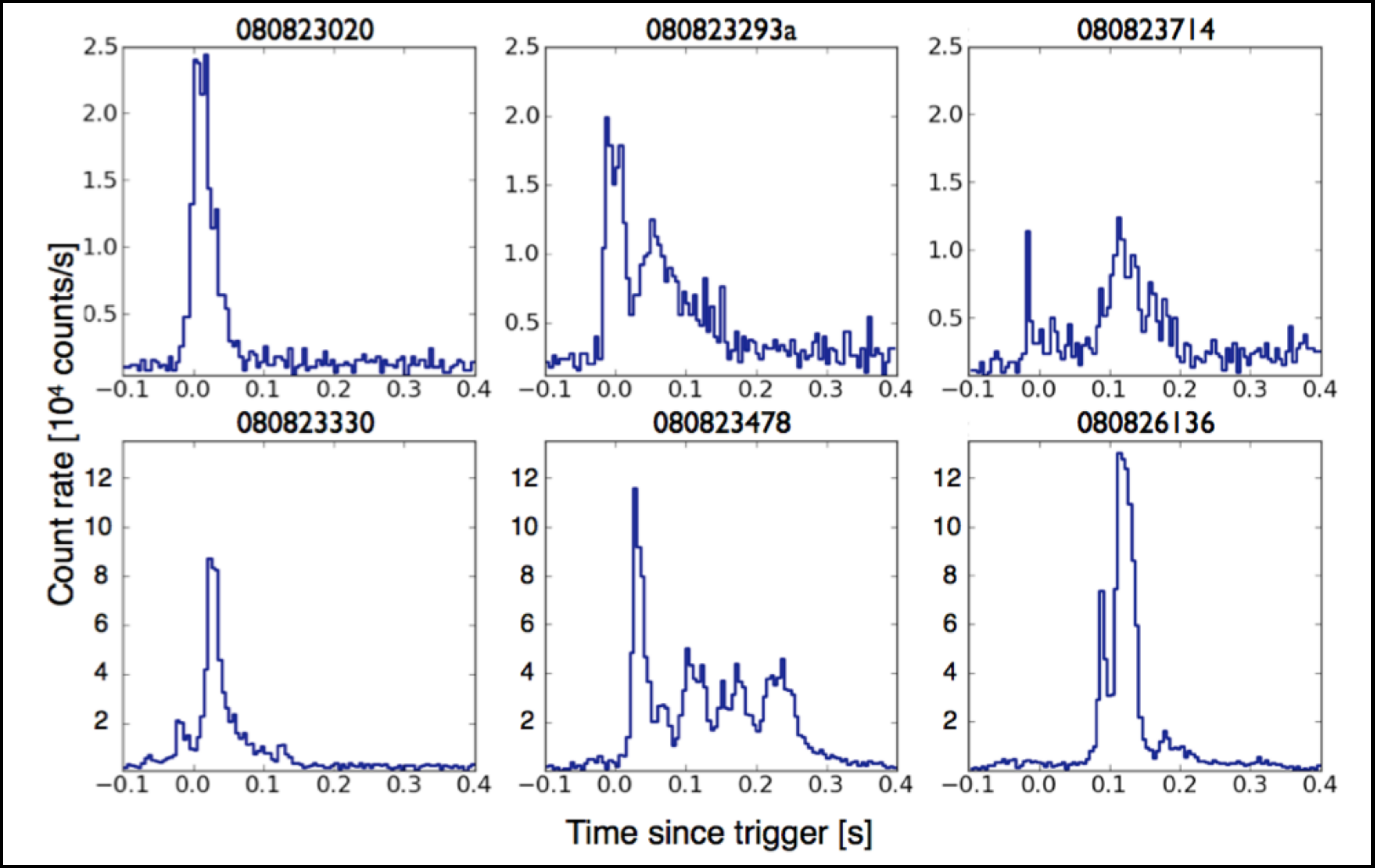
SEISMIC VIBRATION MODELS

- Coupled magneto-torsional oscillations of crust/core.
- Alfven modes are continua: frequency drifts intrinsic.
- Frequencies depend on mass, radius, superfluidity, crust composition, magnetic field strength and geometry.
- Decay times important.



See for example:
Gabler et al. 2013, 14;
Passamonti & Lander 2013,
Huppenkothen, Watts & Levin 2014

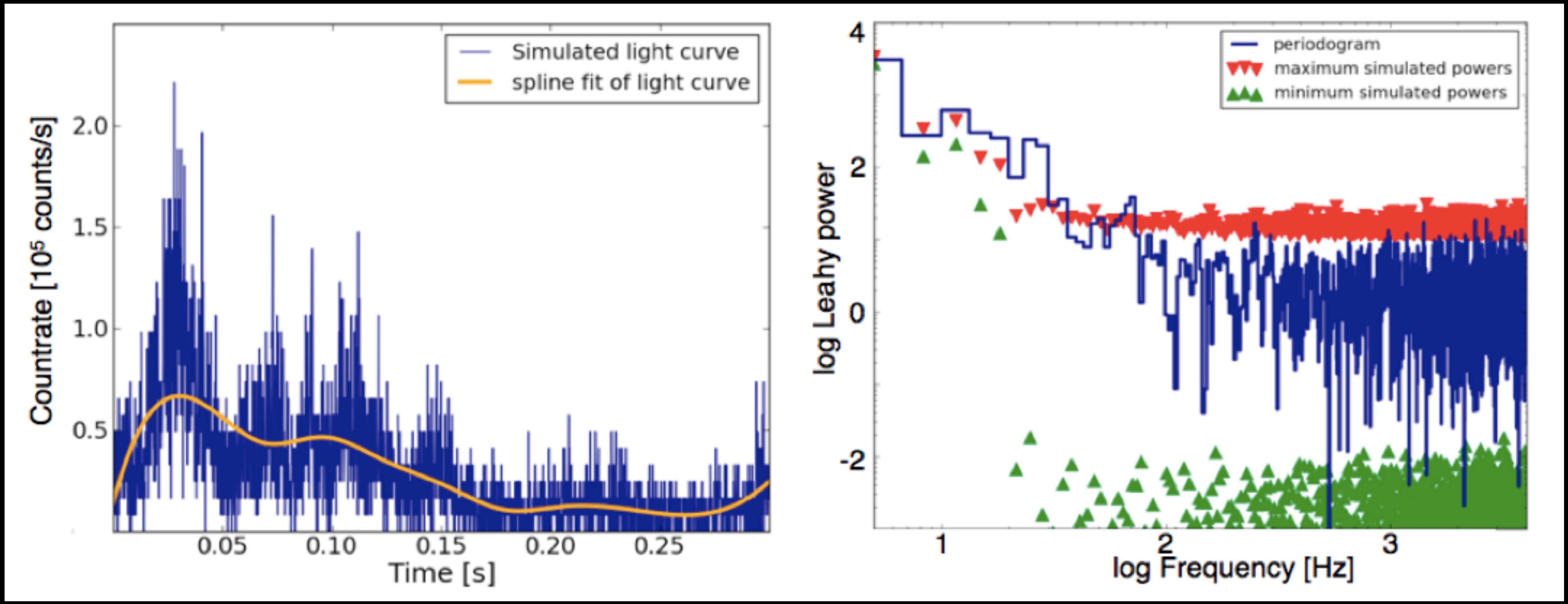
SMALL BURST ASTEROSEISMOLOGY



Fermi GBM bursts from SGR 0501+4516 (Huppenkothen et al. 2013)

SMALL BURST ASTEROSEISMOLOGY

- QPO searches are complicated by the 'burst envelope'.
- Traditional method (Monte Carlo simulations of lightcurves) fails in absence of simple functional model for emission.

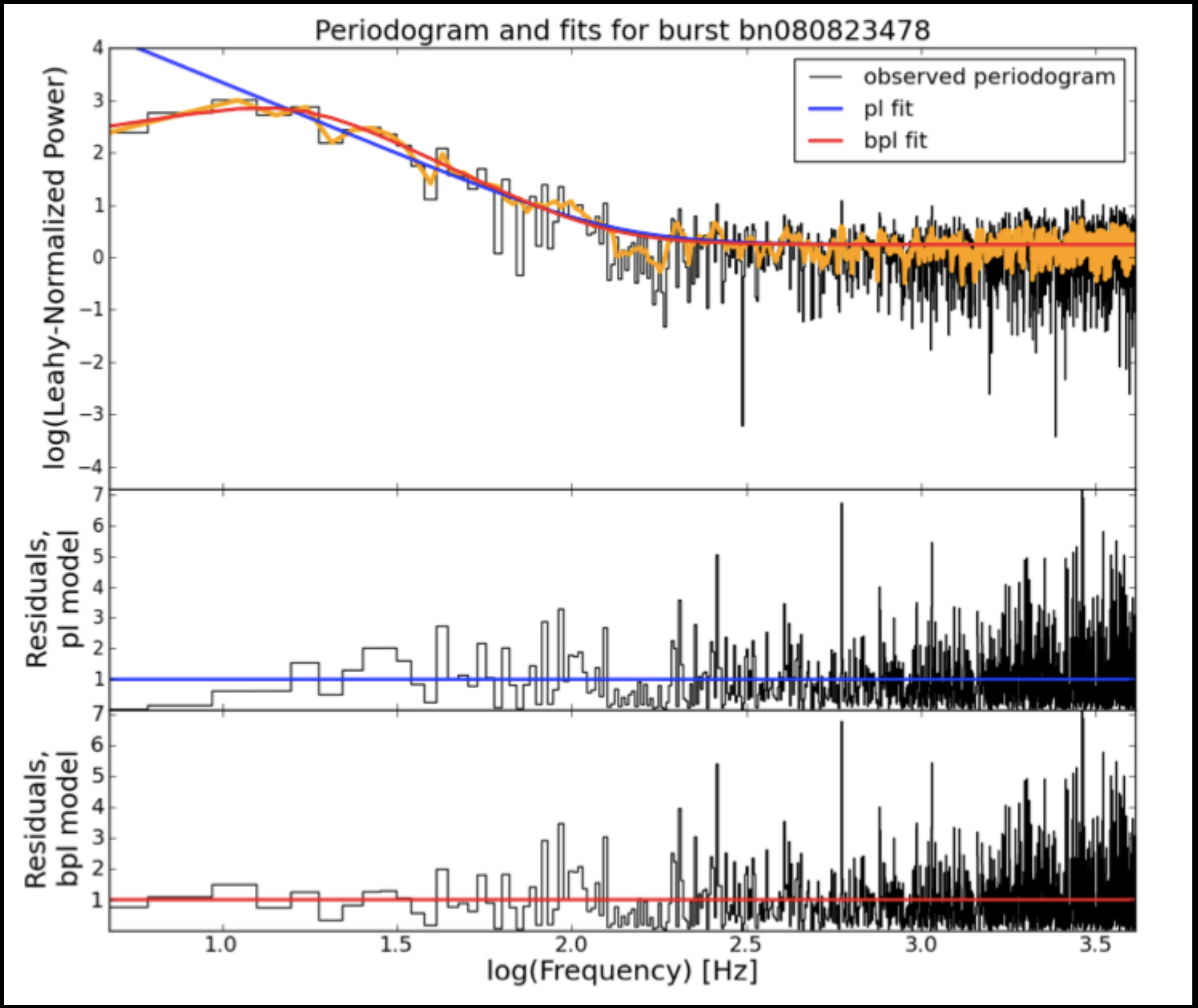


Huppenkothen et al. 2013

SMALL BURST ASTEROSEISMOLOGY

- We use a Bayesian procedure for modelling the periodogram, assuming a red noise process.

- Method is highly conservative.



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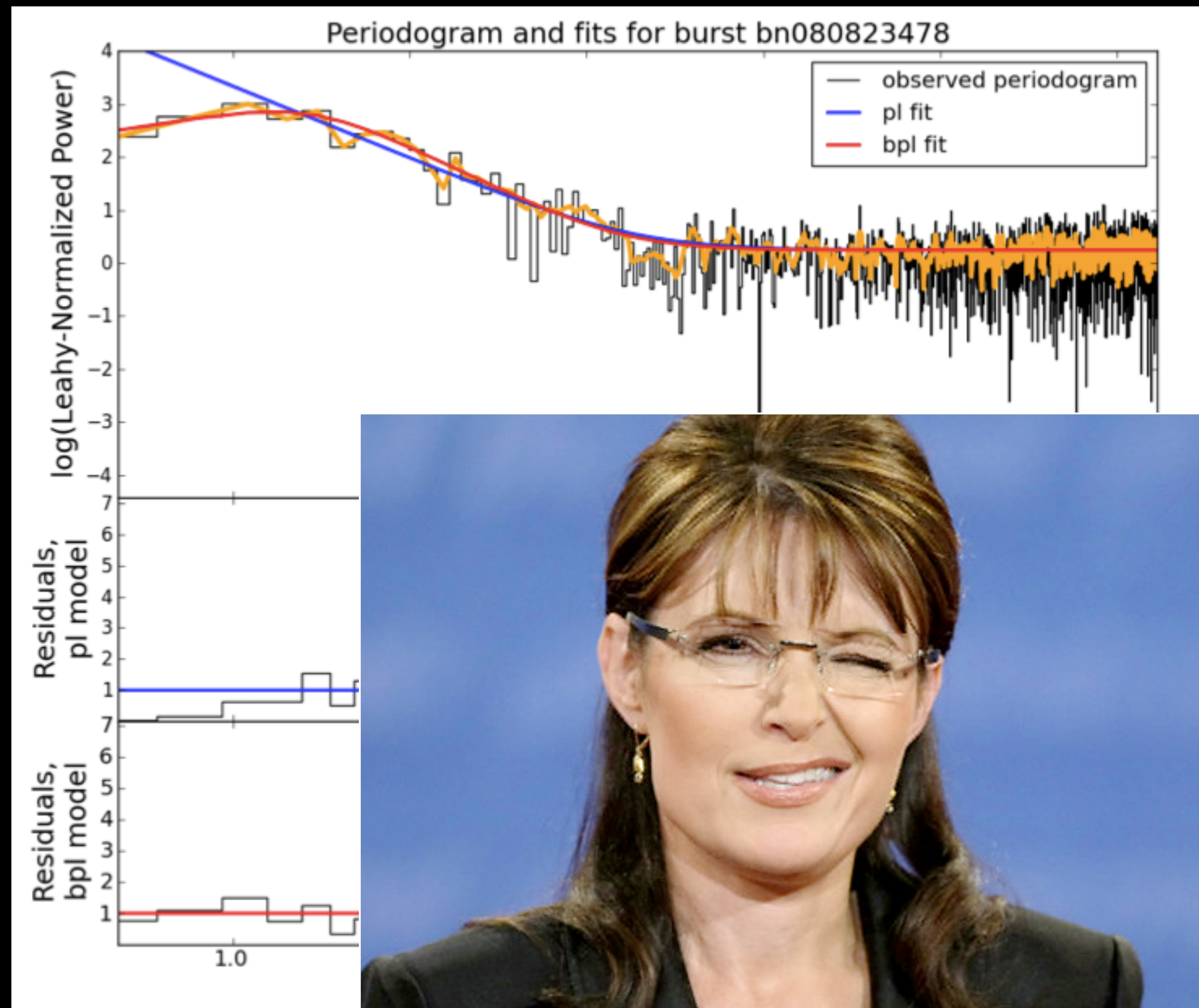
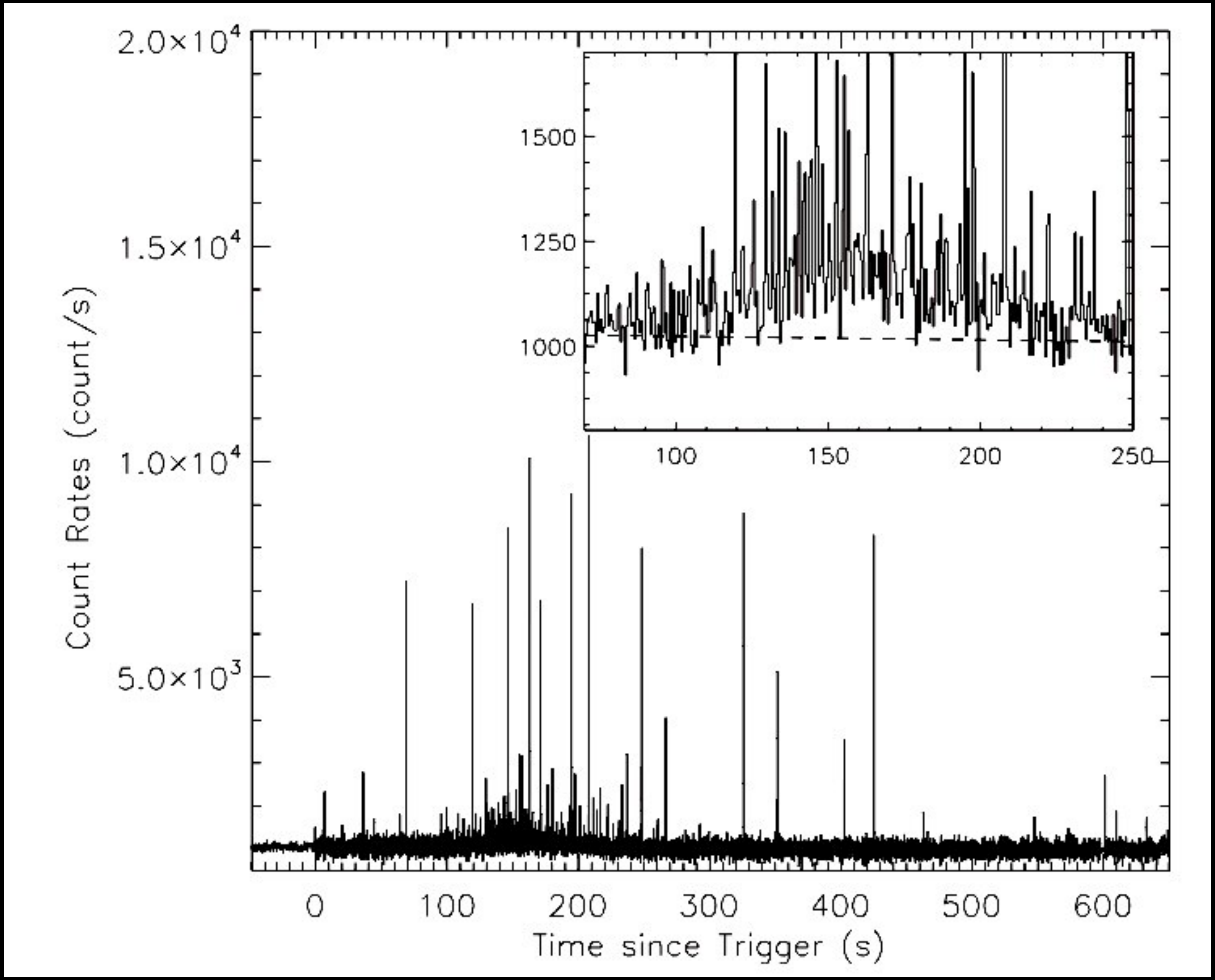


Unofficially known as the ‘Palin Method’

THE SGR J1550-5418 BURST STORM



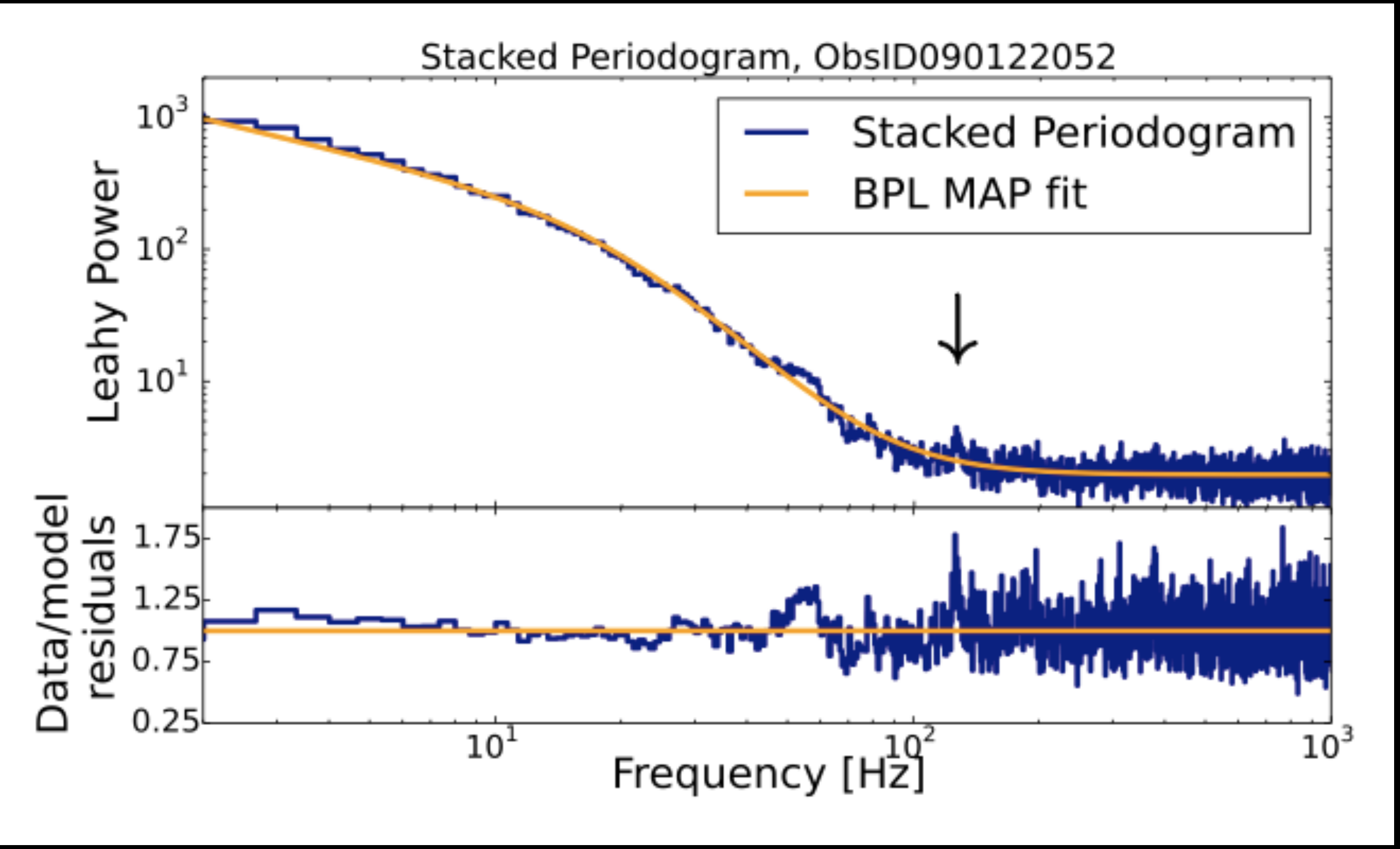
Fermi GBM burst storm, January 2009 (Kaneko et al. 2010, van der Horst et al. 2012)

THE SGR J1550-5418 BURST STORM

- Stacking consecutive bursts in most active periods: Significant QPOs (final $p < 0.001$) in frequency range (93-127 Hz) found in giant flares.

- Similar signals in RXTE data of SGR 1806-20/ SGR 1900+14 bursts.

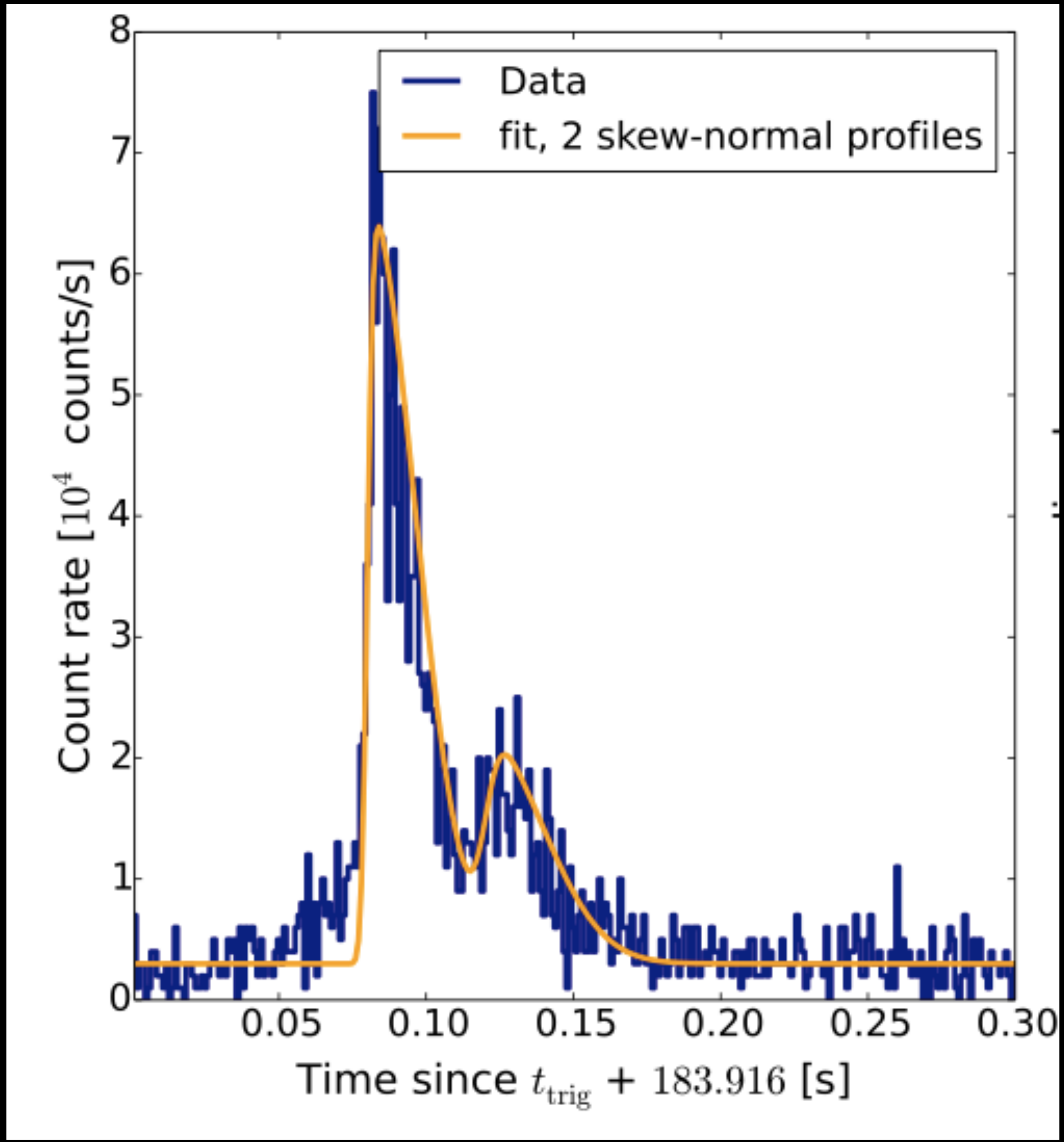
- **Global modes excited by burst storms? Excitation threshold?**



Huppenkothen et al. 2014a, b

THE SGR J1550-5418 BURST STORM

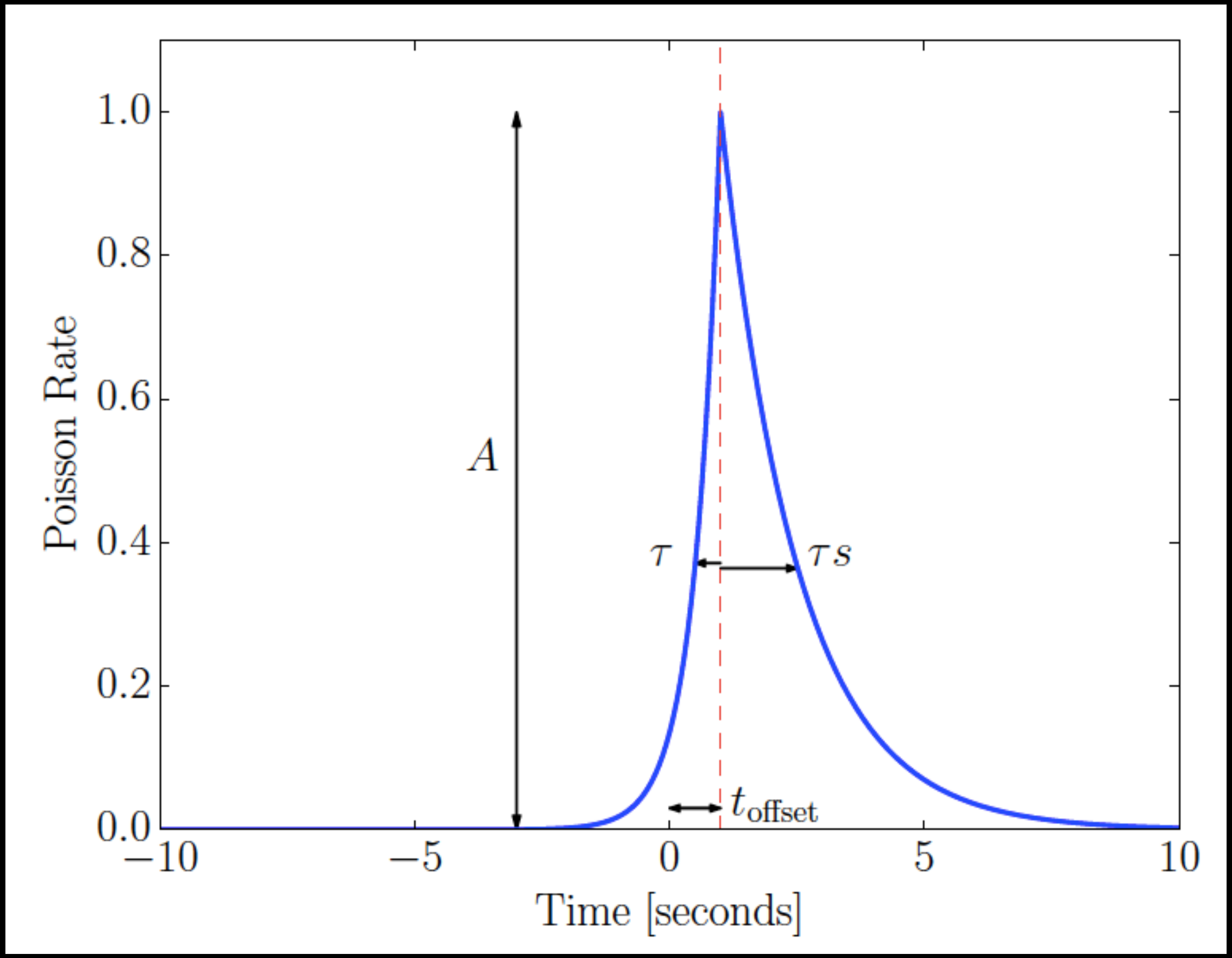
- Single burst: Candidate (final $p < 0.025$) QPO at 260 Hz, different frequency range and broader than giant flare QPOs.
- **Core damping? In line with theoretical predictions.**
- **Signature of trigger mechanism, similar to variability claimed in giant flare peaks?**



Huppenkothen et al. 2014a

LIGHTCURVE MODELS

- Is there a simple empirical function that can generate magnetar burst light curves?
- Bayesian hierarchical models: can bursts can be fit as 'spike cascades'? Yes.
- Testing predictions of simple cascade models for trigger mechanism, including SOC models.



Decompose light curves into superpositions of simple shapes (Huppenkothen et al. in prep).

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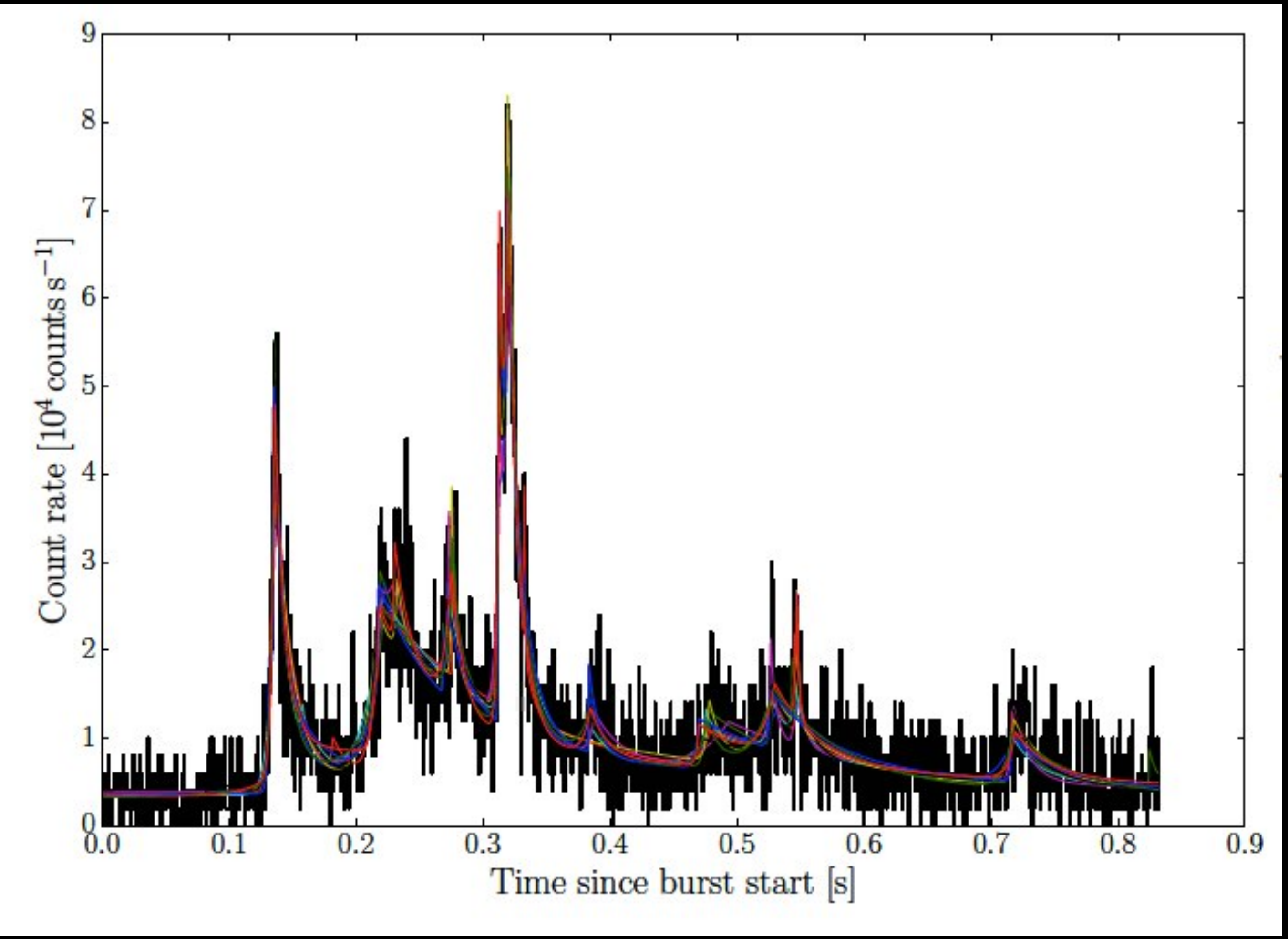

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SUMMARY

- Fermi GBM has given us the first robust detections of seismic vibrations in small magnetar bursts
- QPO pipeline ready for future burst storms and the next giant flare
- Can burst storms excite global vibrations?
- Probing time evolution and variability around the trigger point.