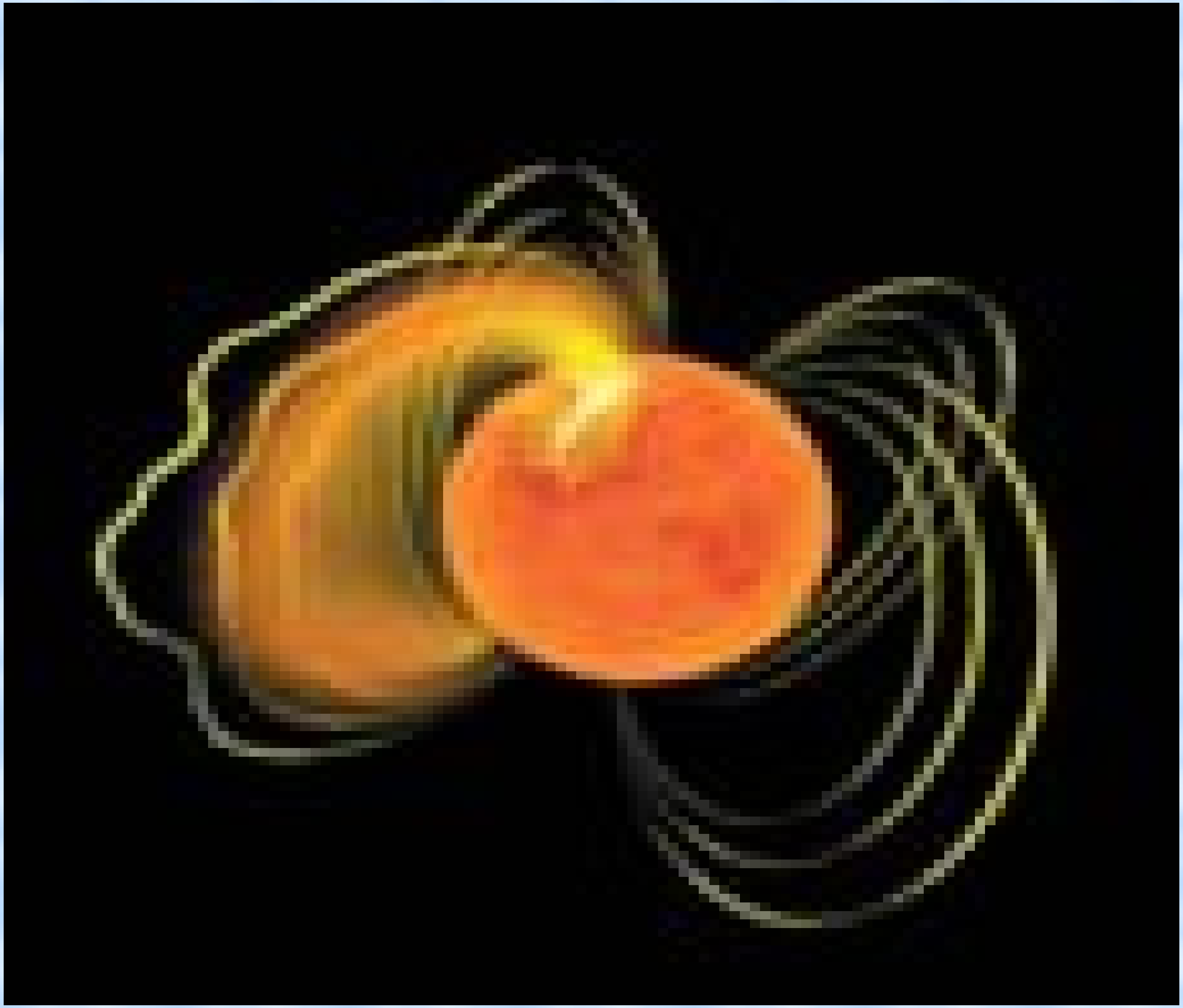
Observations of QPOs in SGR Flare



Jumpei Takata

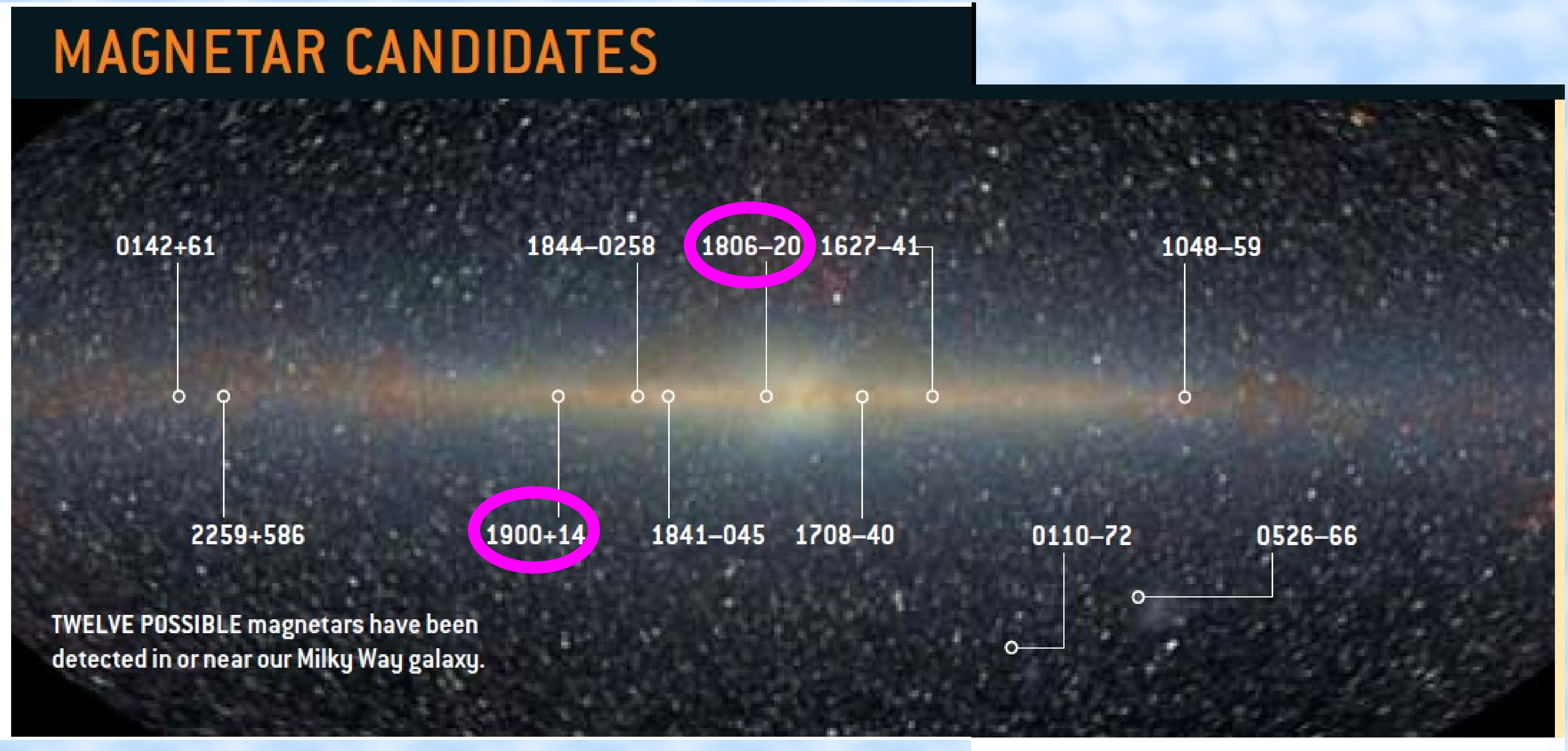
Outline

1. Magnetor
2. QPOs in SGR 1806-20
3. QPOs in SGR 1900+14

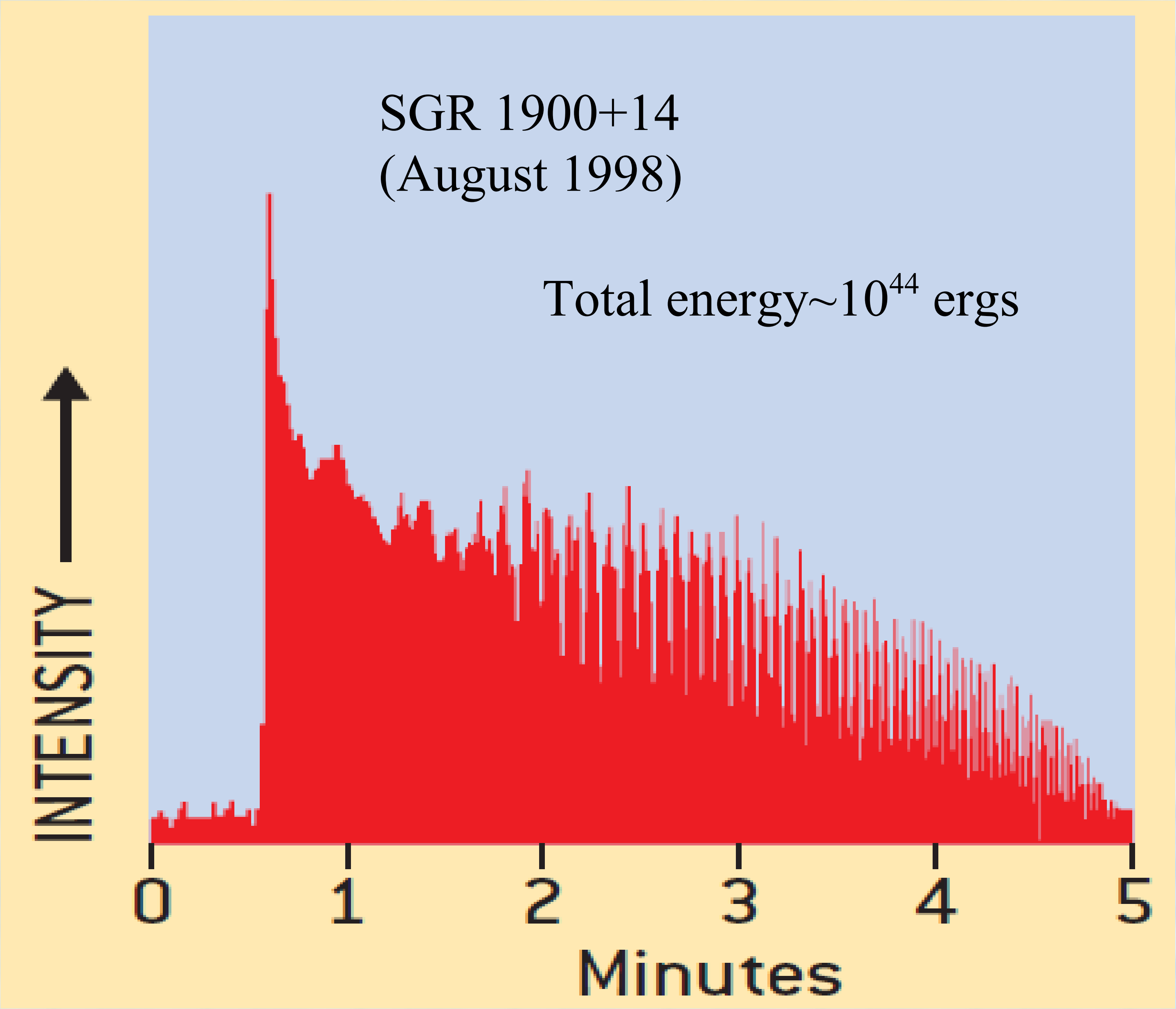
- Israel et al. 2005 ApJL 628, 53
- Strohmayer & Watts, 2005 ApJL 632, 111
- Watts & Strohmayer 2006 ApJL 637, 117
- Strohmayer & Watts, 2006 ApJ 653, 593
- Watts & Strohmayer, 2007 astrph/0612252

Introduction

- Manetars have been considered as very highly magnetized neutron stars.
- Their activities are powered by the decay of a strong magnetic field.

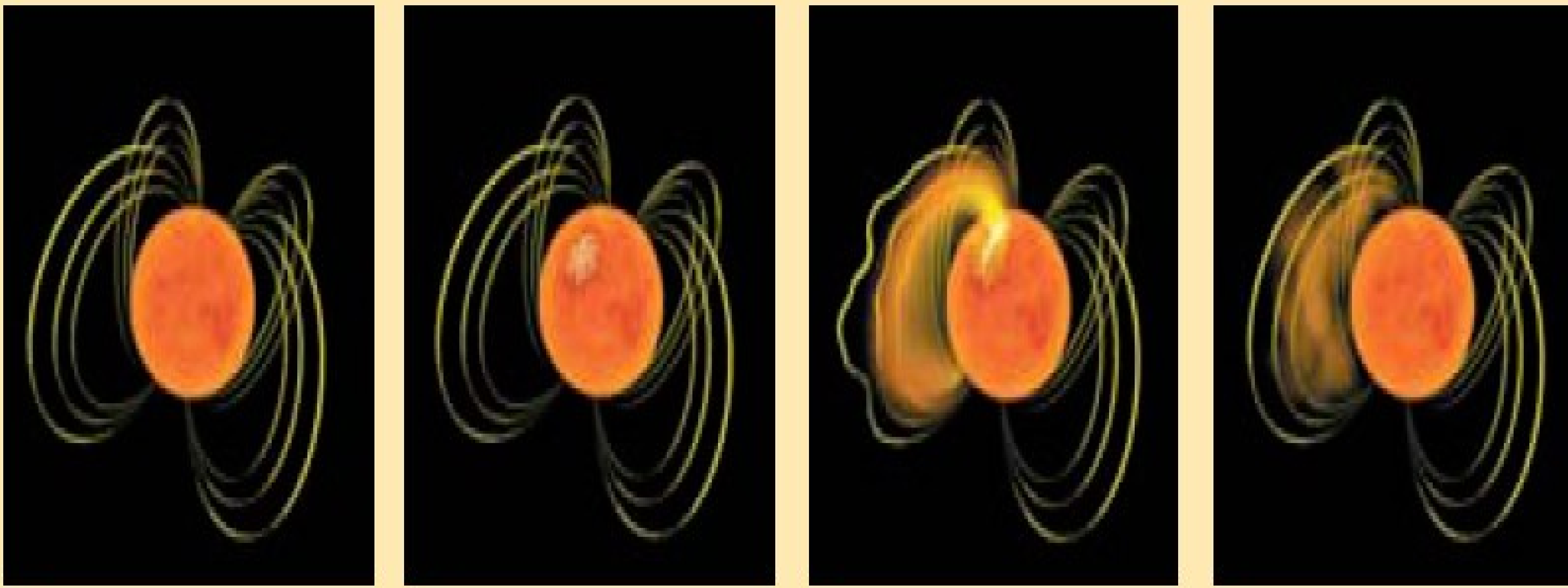


Giant X-ray flare



HOW MAGNETAR BURSTS HAPPEN

THE MAGNETIC FIELD OF THE STAR is so strong that the rigid crust sometimes breaks and crumbles, releasing a huge surge of energy.



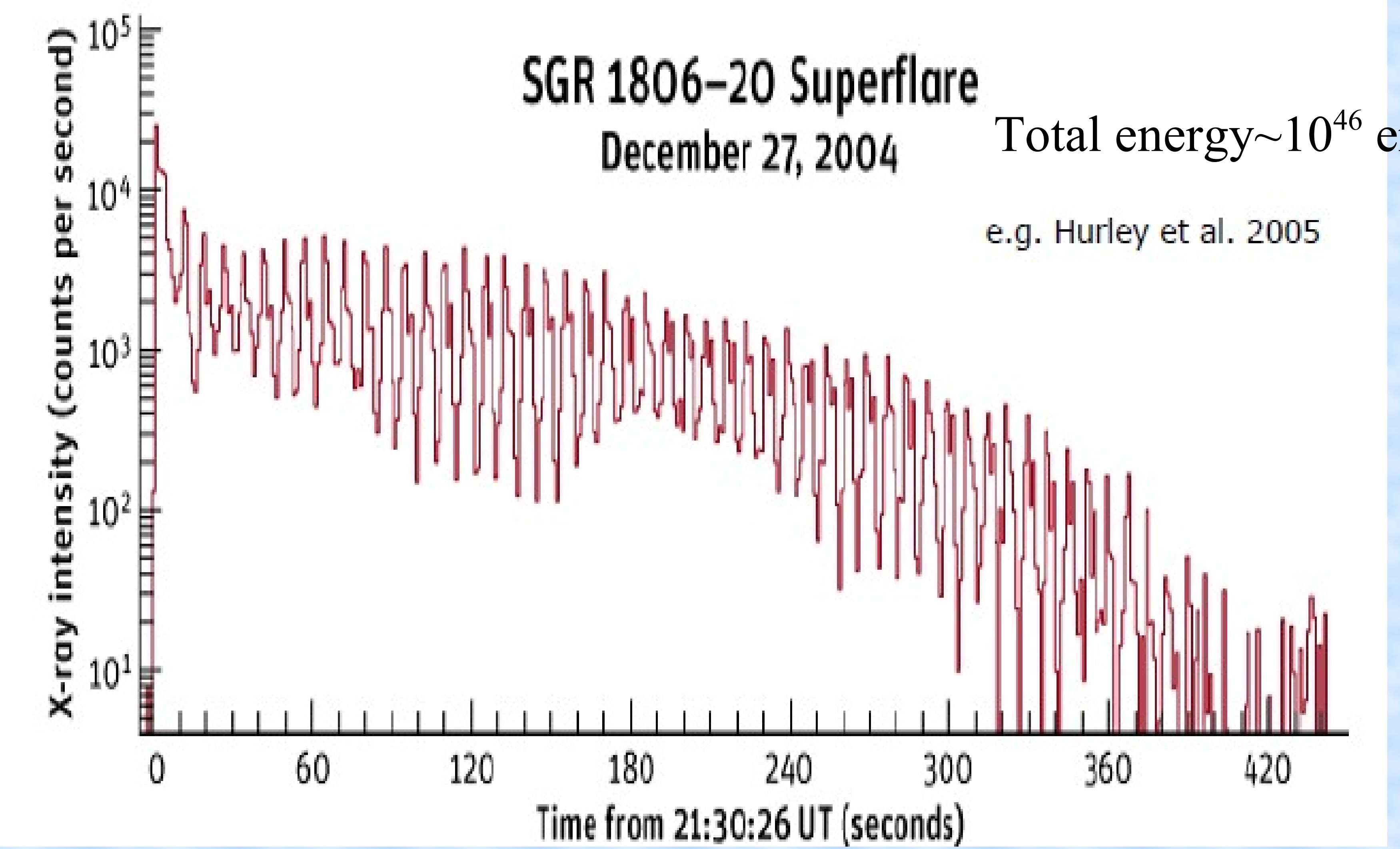
1 Most of the time the magnetar is quiet. But magnetic stresses are slowly building up.

2 At some point the solid crust is stressed beyond its limit. It fractures, probably into many small pieces.

3 This “starquake” creates a surging electric current, which decays and leaves behind a hot fireball.

4 The fireball cools by releasing x-rays from its surface. It evaporates in minutes or less.

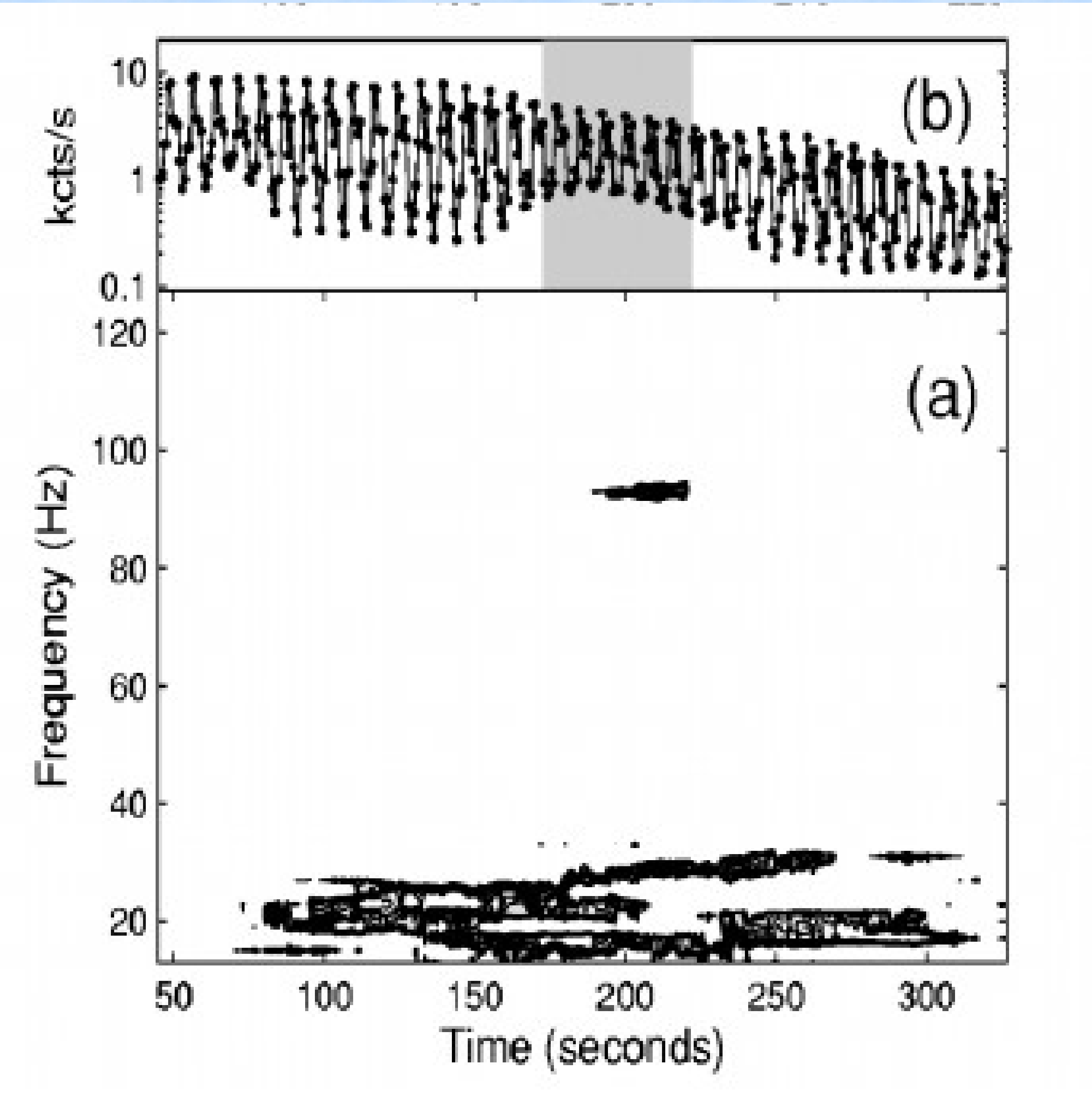
QPOs in SGR 1806-20

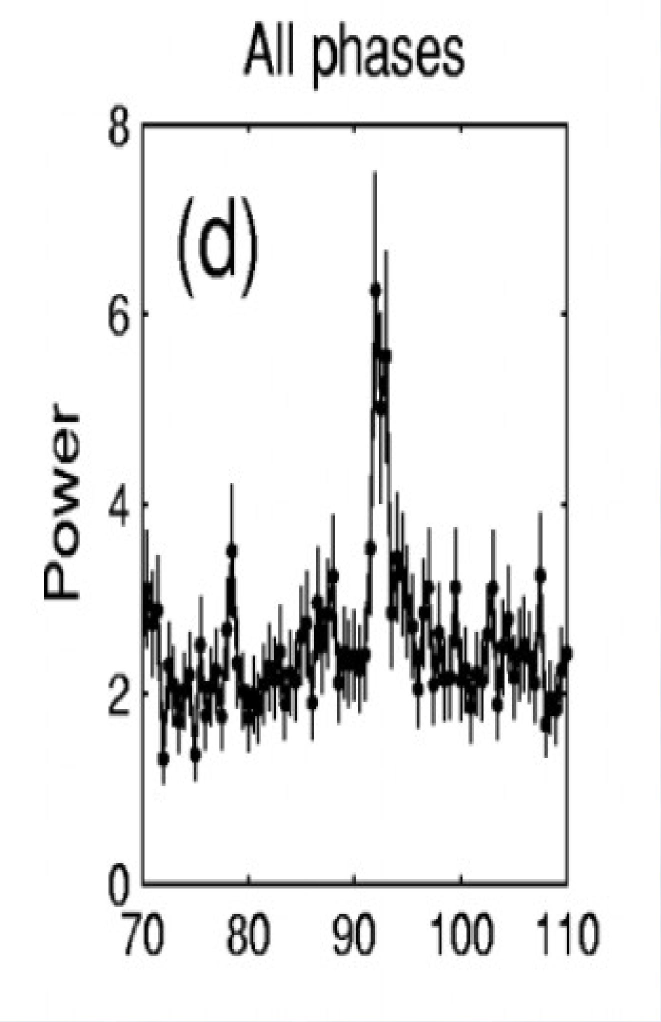


Total energy~10^{46} ergs

e.g. Hurley et al. 2005

~90Hz QPOs
(@170-220s after burst)



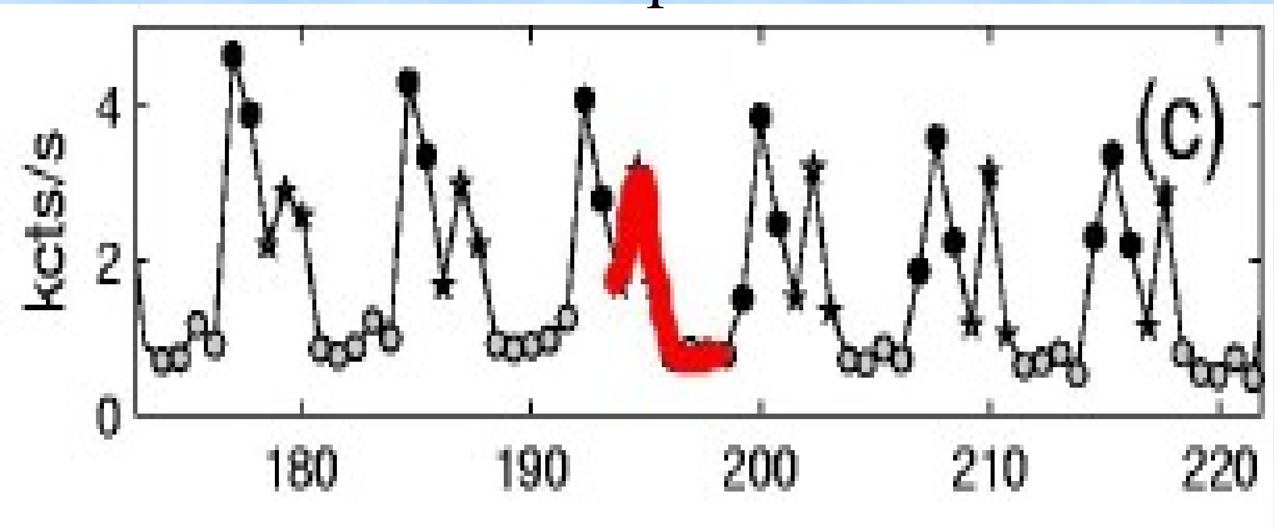


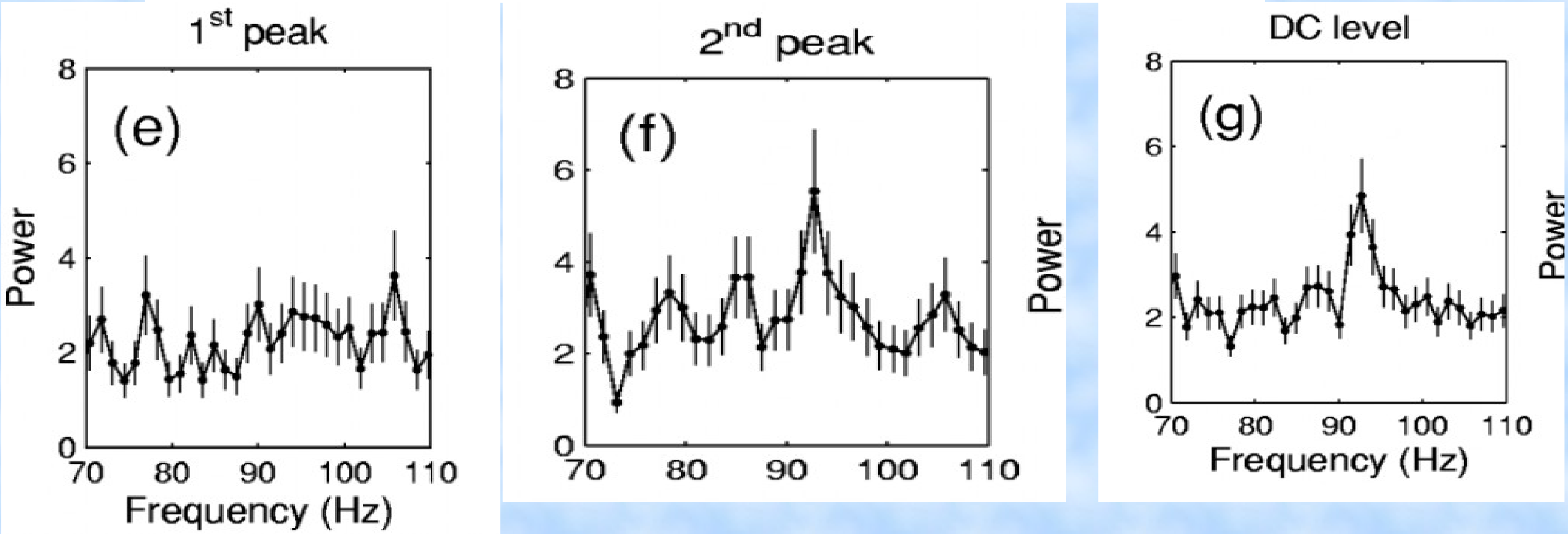
ISRAEL et al. 2005

~90Hz QPOs
(not seen at 1st peak)

ISRAEL et al. 2005

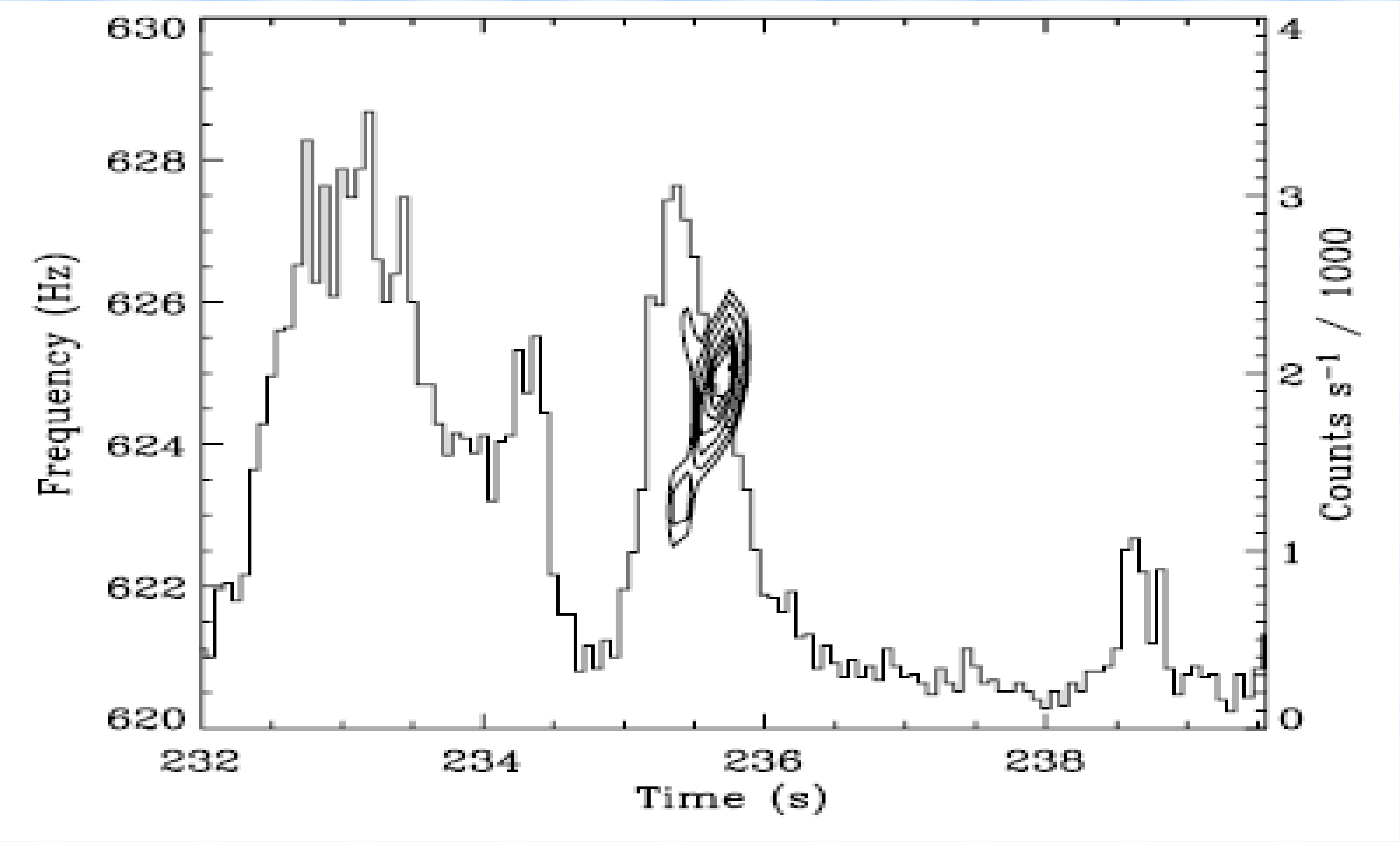
Pulse profiles





~625Hz QPO

STROHMAYER & Watts 2006



STROHMAYER & Watts 2006

TABLE 1

SUMMARY OF PROPERTIES FOR THE MOST SIGNIFICANT QPOs DETECTED IN THE TAIL OF THE SGR 1806−20 GIANT FLARE

Frequency (Hz)	Width (Hz)	rms Amplitude (%)	Duration (s)	Phase	Satellite	Notes
17.9 ± 0.1	1.9 ± 0.2	4.0 ± 0.3	60–230	P2/I	*RHESSI*	1
25.7 ± 0.1	3.0 ± 0.2	5.0 ± 0.3	60–230	P2/I	*RHESSI*	1
29.0 ± 0.4	4.1 ± 0.5	20.5 ± 3.0	190–260	P2/I	*RXTE*	2
92.5 ± 0.2	$1.7^{+0.7}_{-0.4}$	10.7 ± 1.2	150–260	P2/I	*RXTE*	3
92.7 ± 0.1	2.3 ± 0.2	10.3 ± 0.8	150–260	P2/I	*RHESSI*	1, 4
92.9 ± 0.2	2.4 ± 0.3	19.2 ± 2.0	190–260	P2/I	*RXTE*	2, 5
150.3 ± 1.6	17 ± 5	6.8 ± 1.3	10–350	P1	*RXTE*	2
626.46 ± 0.02	0.8 ± 0.1	20 ± 3	50–200	P1	*RHESSI*	1, 6
625.5 ± 0.2	1.8 ± 0.4	8.5 ± 1.8	190–260	P2/I	*RXTE*	2
1837 ± 0.8	4.7 ± 1.2	18.0 ± 3.6	230–245	P2/I	*RXTE*	2

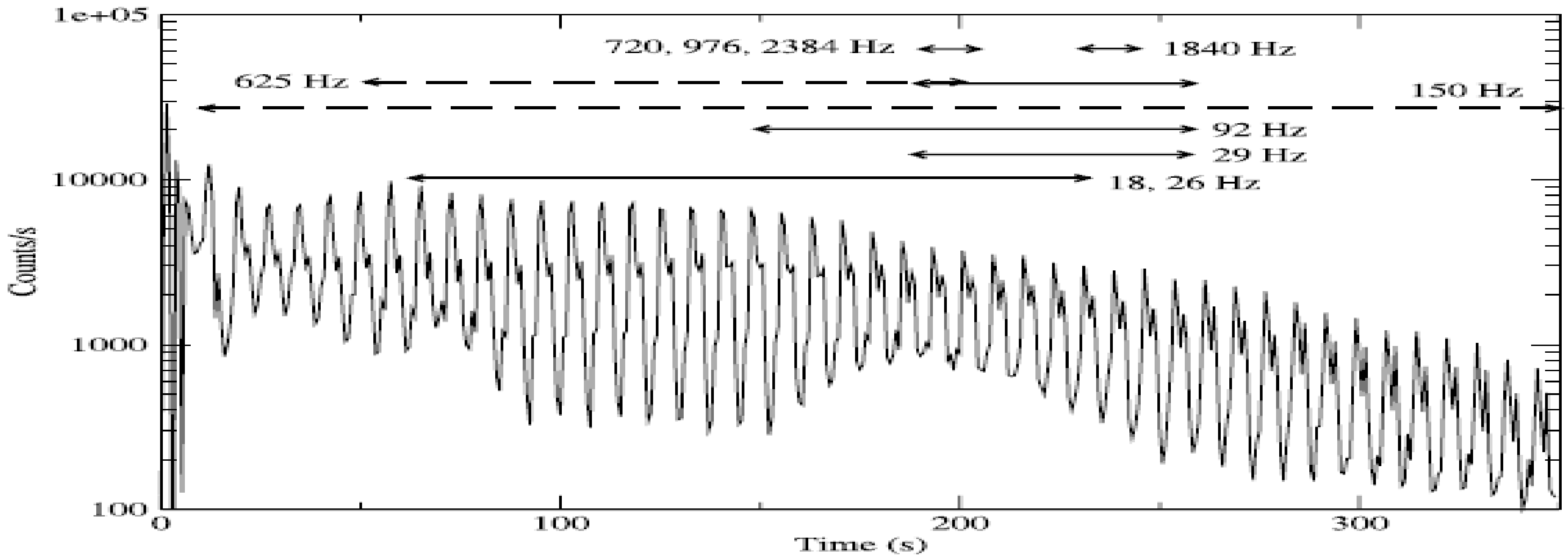
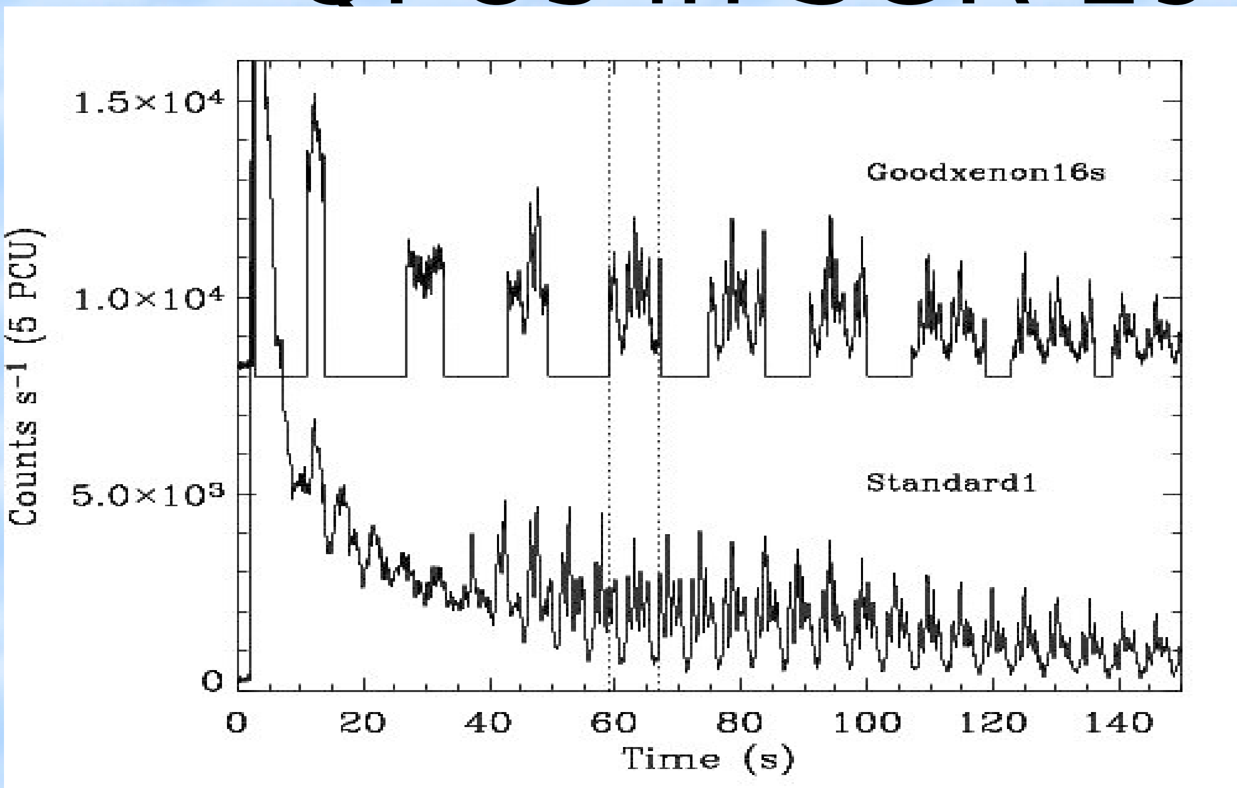


FIG. 10.—Time periods when the different QPOs are detectable in either the *RXTE* or *RHESSI* data sets. Solid lines indicate QPOs that are detected in the peak 2/interpulse region. Dashed lines indicate QPOs that are detected primarily during peak 1. The difference in properties between the two ≈625 Hz QPOs, the earlier one detected by *RHESSI* and the later one by *RXTE*, is clear.

QPOs in SGR 1900+14



STROHMAYER & Watts 2005

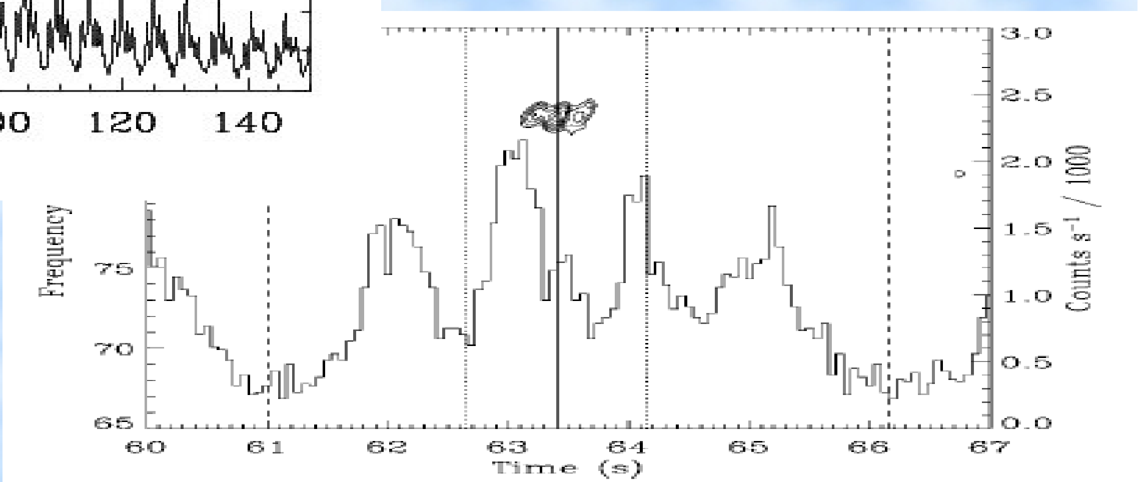
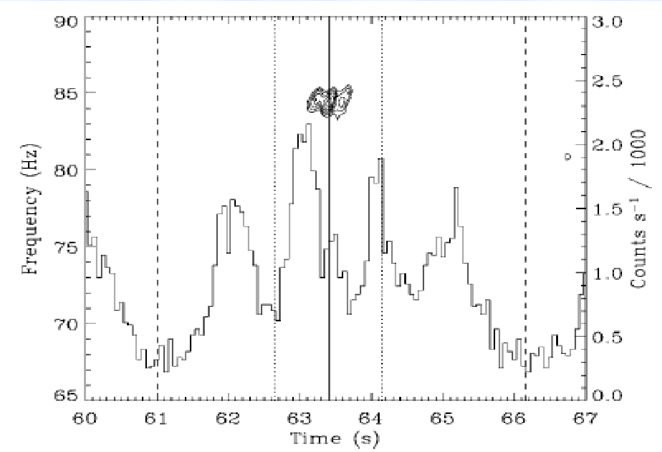


FIG. 3.—Dynamic power spectrum of the data interval containing the QPO. Spectral power contours were computed from 0.5 s segments, with a new segment beginning every 0.1 s. The lowest and highest contours correspond to single trial probabilities of 4.5×10^{-5} and 1.7×10^{-10}, respectively. The signal is localized near the brightest peak of the four-peaked profile, but it is not centered on the peak. The vertical dotted lines denote the phase range used to compute average power spectra (see Fig. 4). The vertical solid line marks the center of this range. One rotational cycle (5.16 s period) is marked by the vertical dashed lines. The timescale is the same as in Fig. 1.

STROHMAYER & Watts 2005



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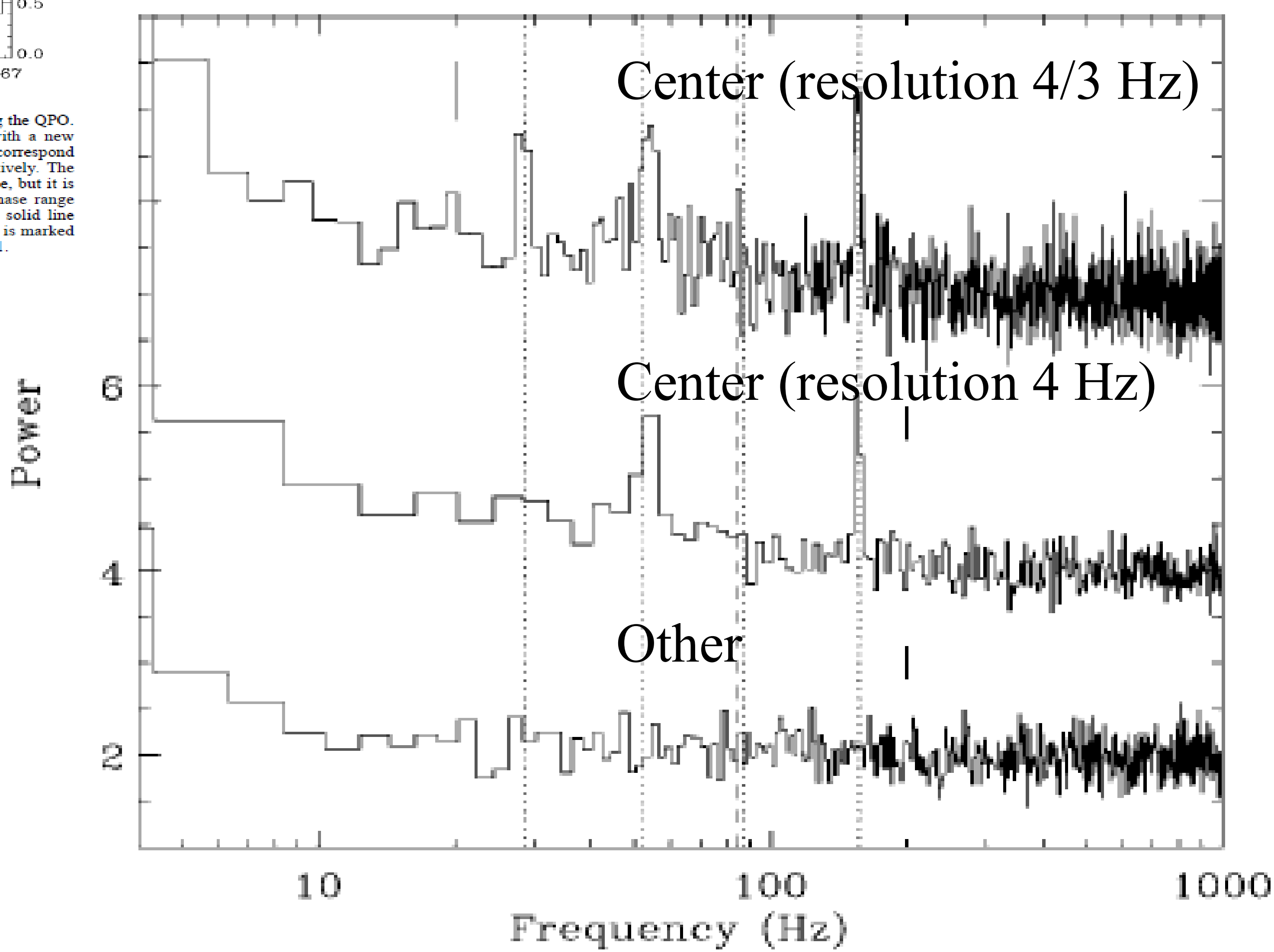
~28 Hz
~53.5Hz
~84 Hz
~155.1 Hz



Summary

- The QPOs were detected in the tail of giant flare of SGR 1806-20 and SGR 1900-14
- The detected QPO properties depend on the rotational phase and the times after the burst.
- This oscillation during the giant flares may be first detection of vibrations in the neutron star crust.

A mode sequence?

STROHMAYER & Watts 2005

Vibration of the neutron star crust?

$$P(\ _2t_0)=33.6\mathrm{R}_{10}\frac{0.87+0.13\mathrm{M}_{1.4}R_{10}^{-2}}{(1.71-0.71\mathrm{M}_{1.4}R_{10}^{-1})^{1/2}}$$

$$P(\ _lt_0)=P(\ _2t_0)\left[\frac{6}{l(l+1)}\right]^{1/2}\left[1+\left(\frac{B}{B_\mu}\right)^2\right]^{-1/2}$$

l= 2 4 7 13