Comparison of the damped oscillations in solar and stellar soft X-ray flares

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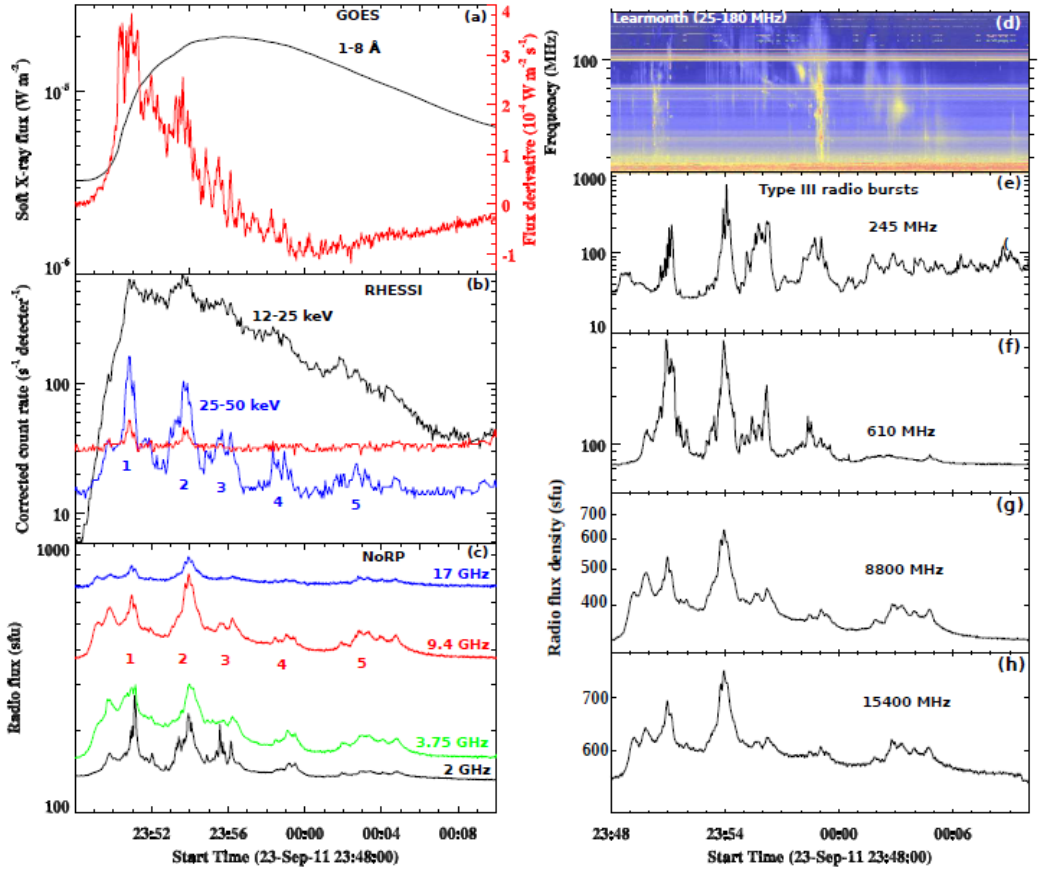
Contents

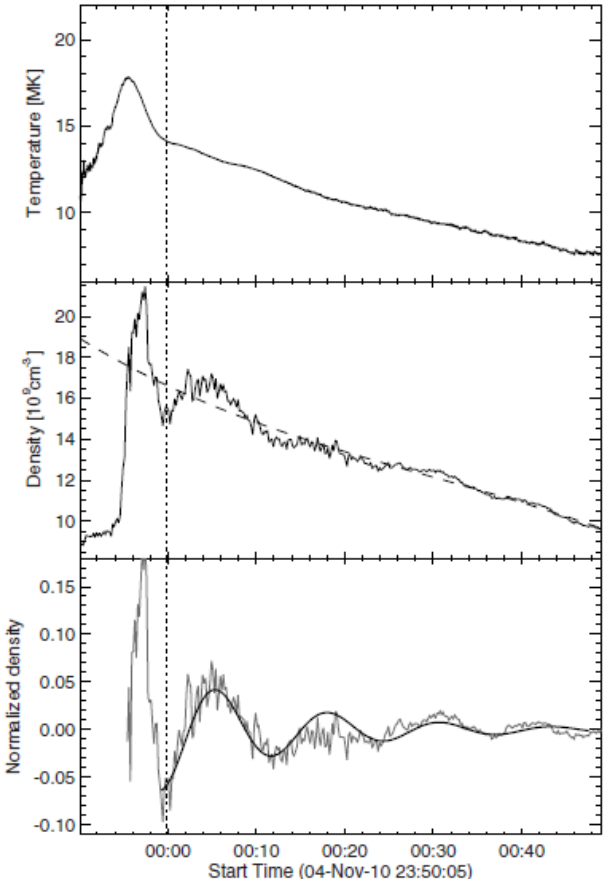
QPPs in the Solar Flares

Kumar et al. (2016)



Non thermal emissions

Kim et al. (2012)



Thermal emissions

(1) Non-Thermal QPPs

: Periodic reconnection by

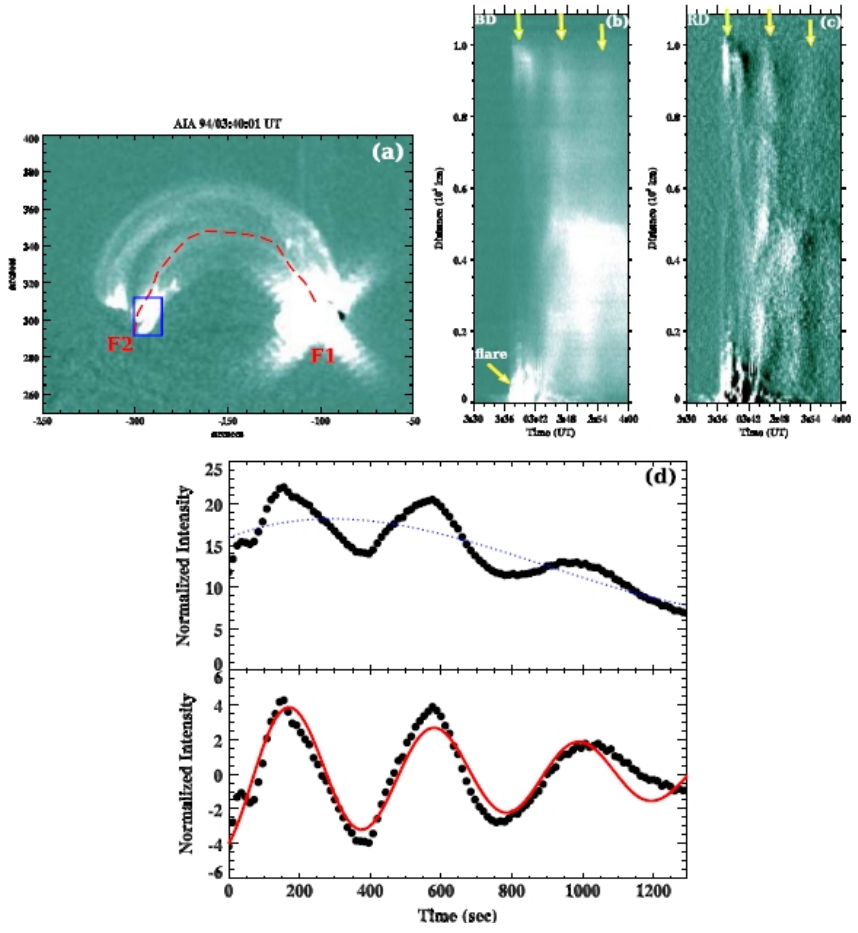
- sunspot wave (Kumar ea 2016; Sych ea 2015, 3 min),
- multiple plasmoids (Kliem ea 2000),
- sausage mode wave (Inglis ea 2008, 16 s),
  or 2nd harmonic of slow mode wave
  (Reznikova and Shibasaki, 2011, 2.5-5 min)

(2) Thermal QPPs

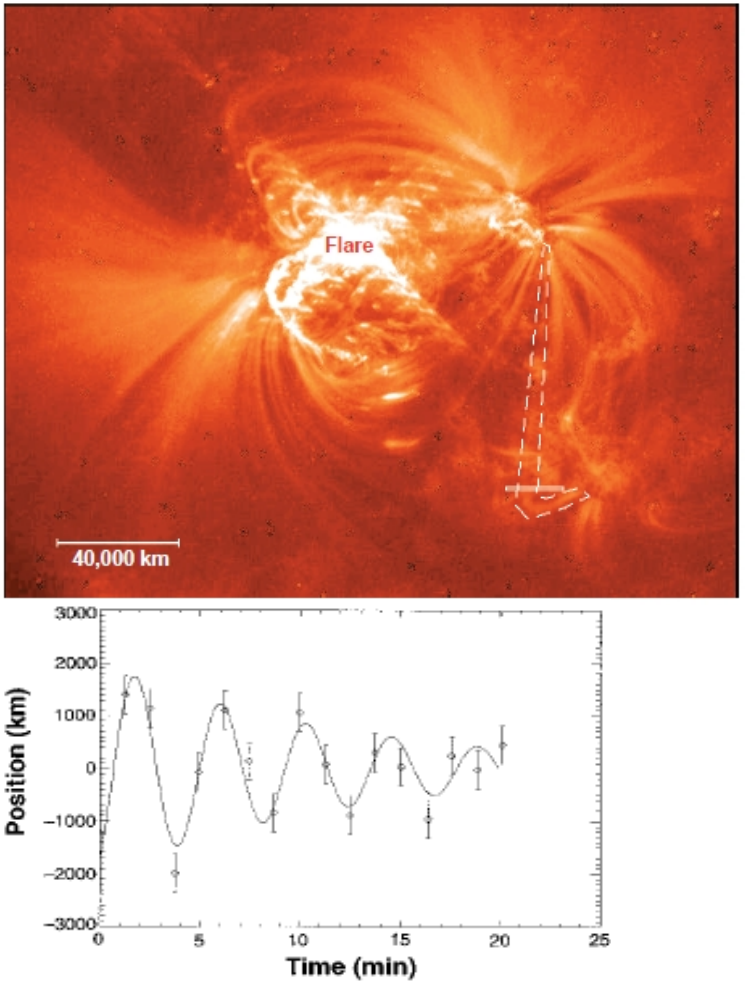
: Slow Longitudinal oscillation in the Hot Loop (Wang ea 2003, 7-31 min)

: Transverse oscillation in the Cool Loop (Aschwanden ea 2002, 2-33 min)

Solar QPPs with Thermal Emissions in Hot and Cool Loops



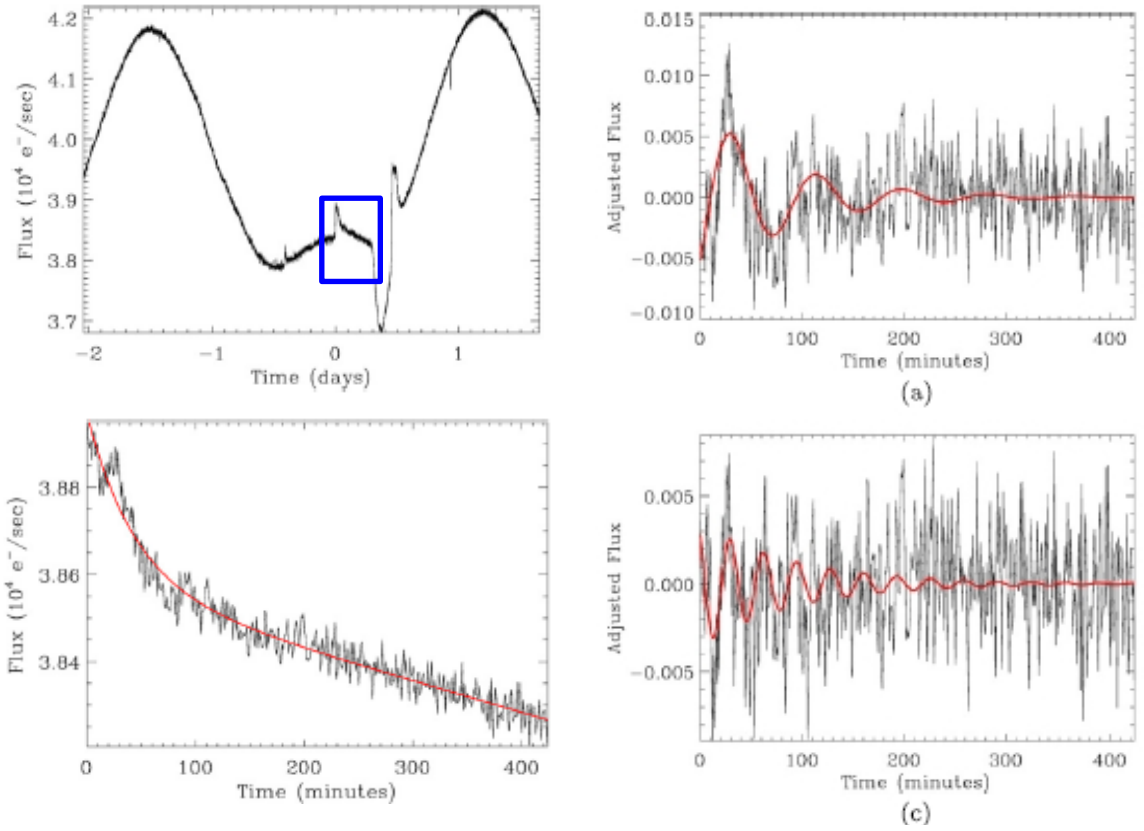
Kumar et al. (2015)



Nakariakov et al. (1999)

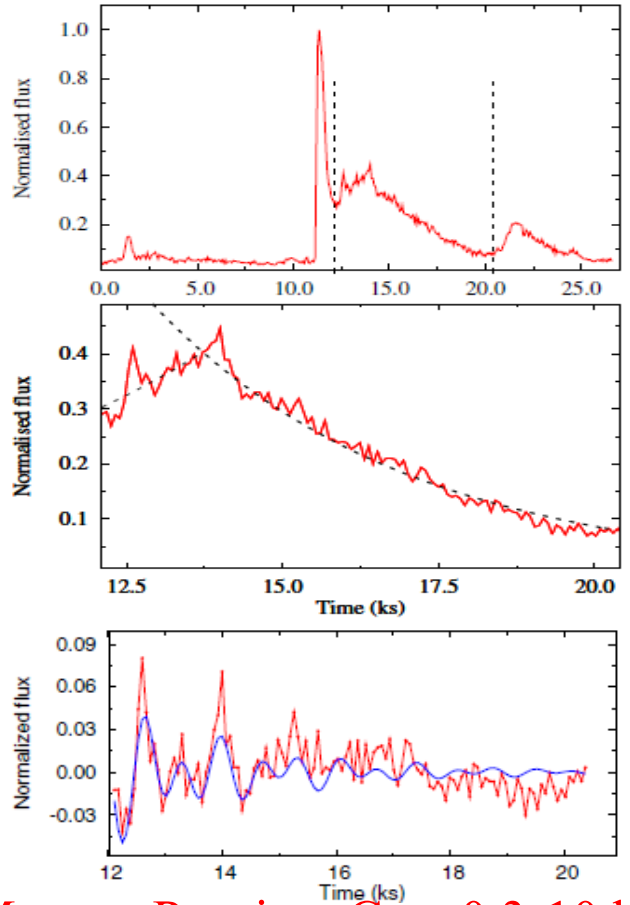
QPPs in Stellar flares

Pugh et al. (2015)



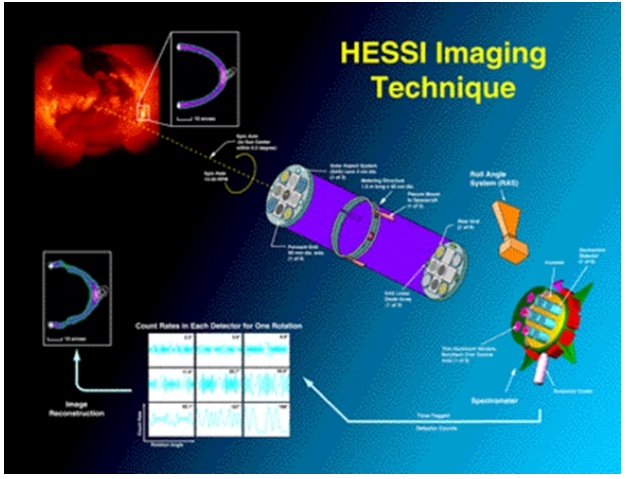
K-type binary, KIC 9655129, White light

Srivastava et al. (2013)



M-type, Proxima Cen, 0.3-10 keV

There is still no example of QPP in the solar white light.
But, a comparison of solar and stellar QPPs at X-ray could be established.



Solar QPPs

- RHESSI soft X-ray flares in 2014 (59 events)

< 12 keV, mostly M-class, few X- and C- class

- RHESSI light curve using *solarsoft* package

Stellar QPPs

- XMM-Newton soft X-ray flares in Dwarfs (52 events)

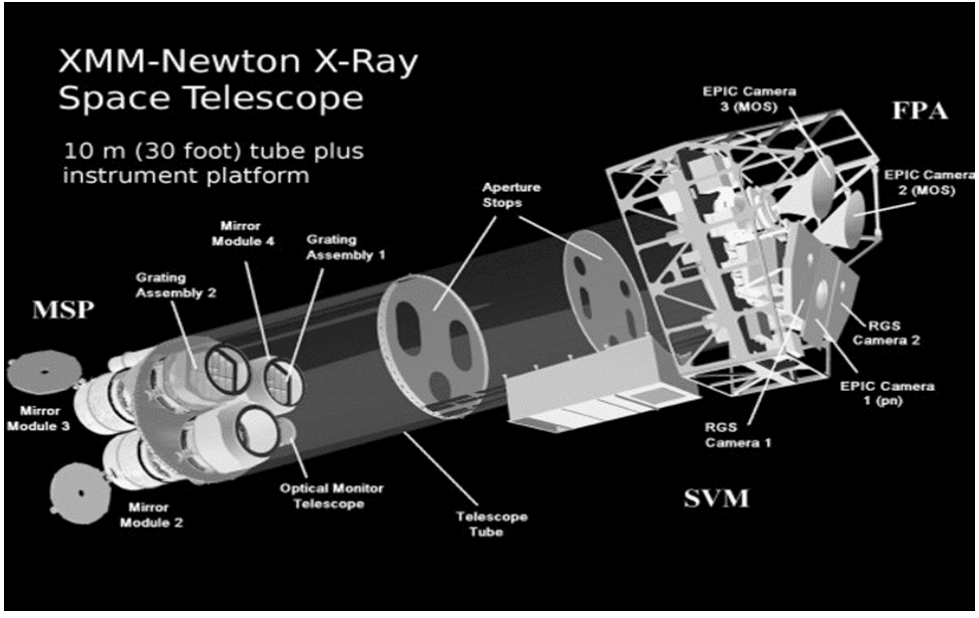
: 0.3 – 2 keV

- XMM-Newton light curve using SAS 13.0

: pre-processing – *em(p)roc*

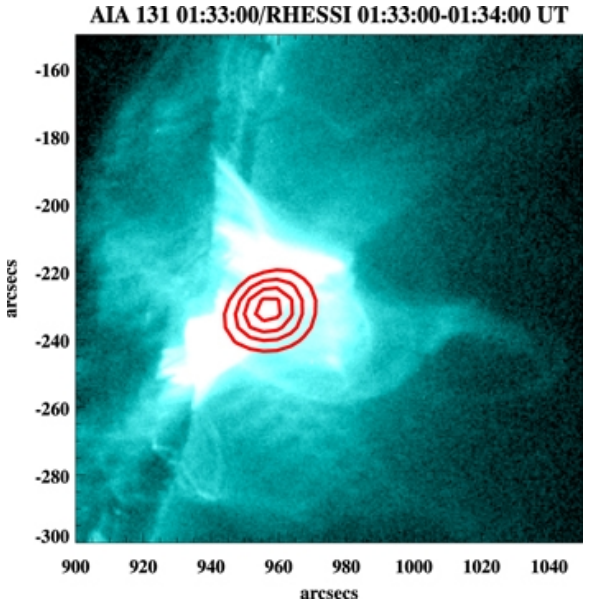
: src and bkg light curve - *Evselect*

: light curve correction – *epiclccorr*

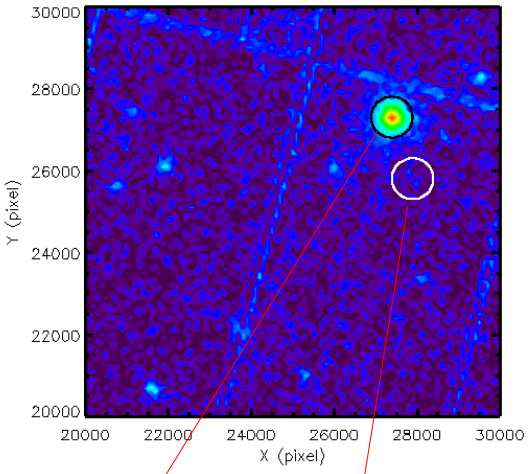


Data

Local intensity

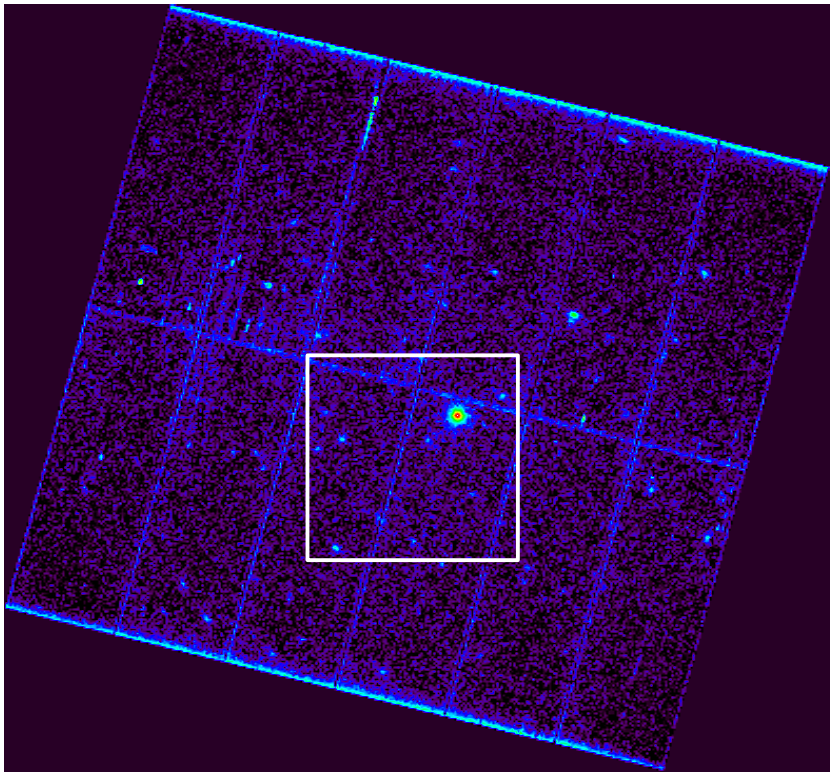


Global intensitv

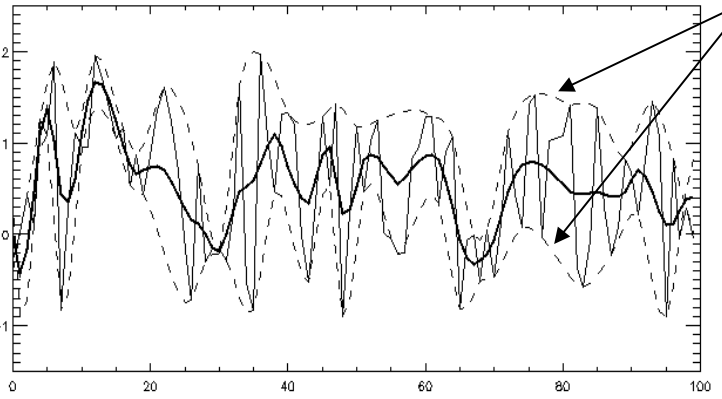


Source

Background

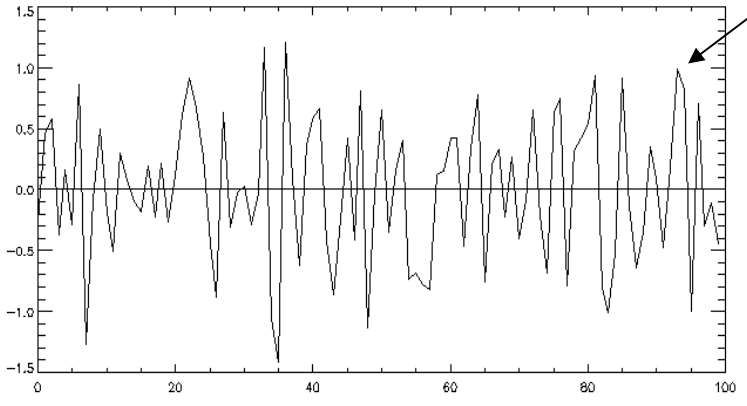


Empirical Mode Decomposition (Huang et al. 1998)



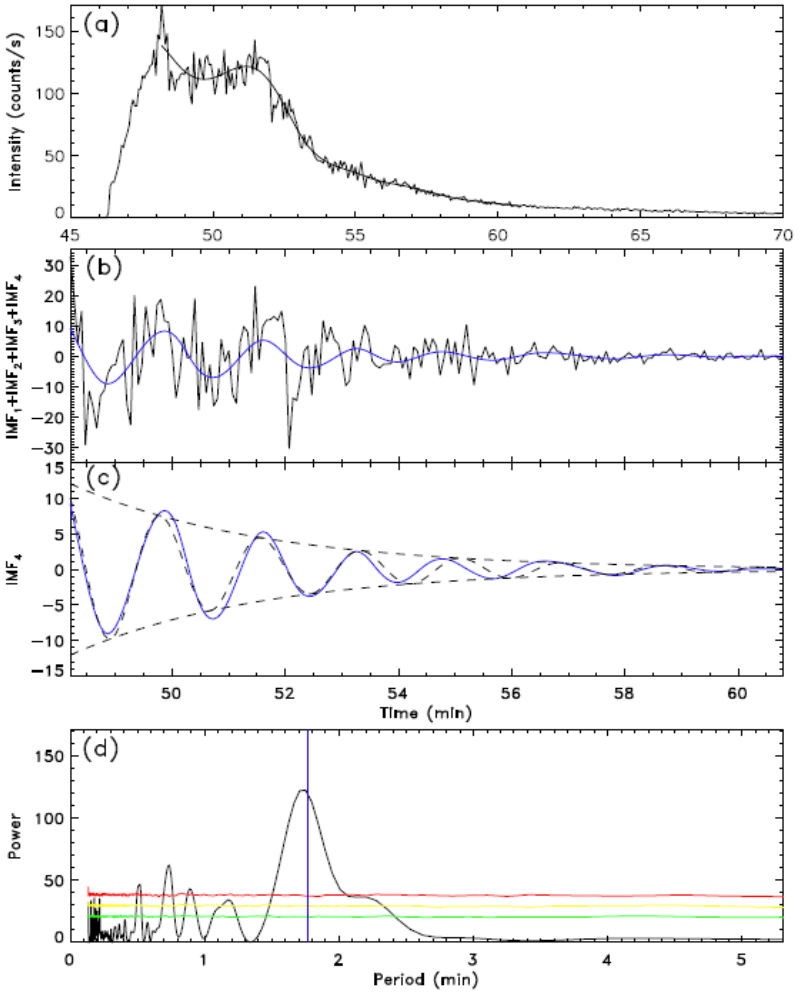
Envelopes

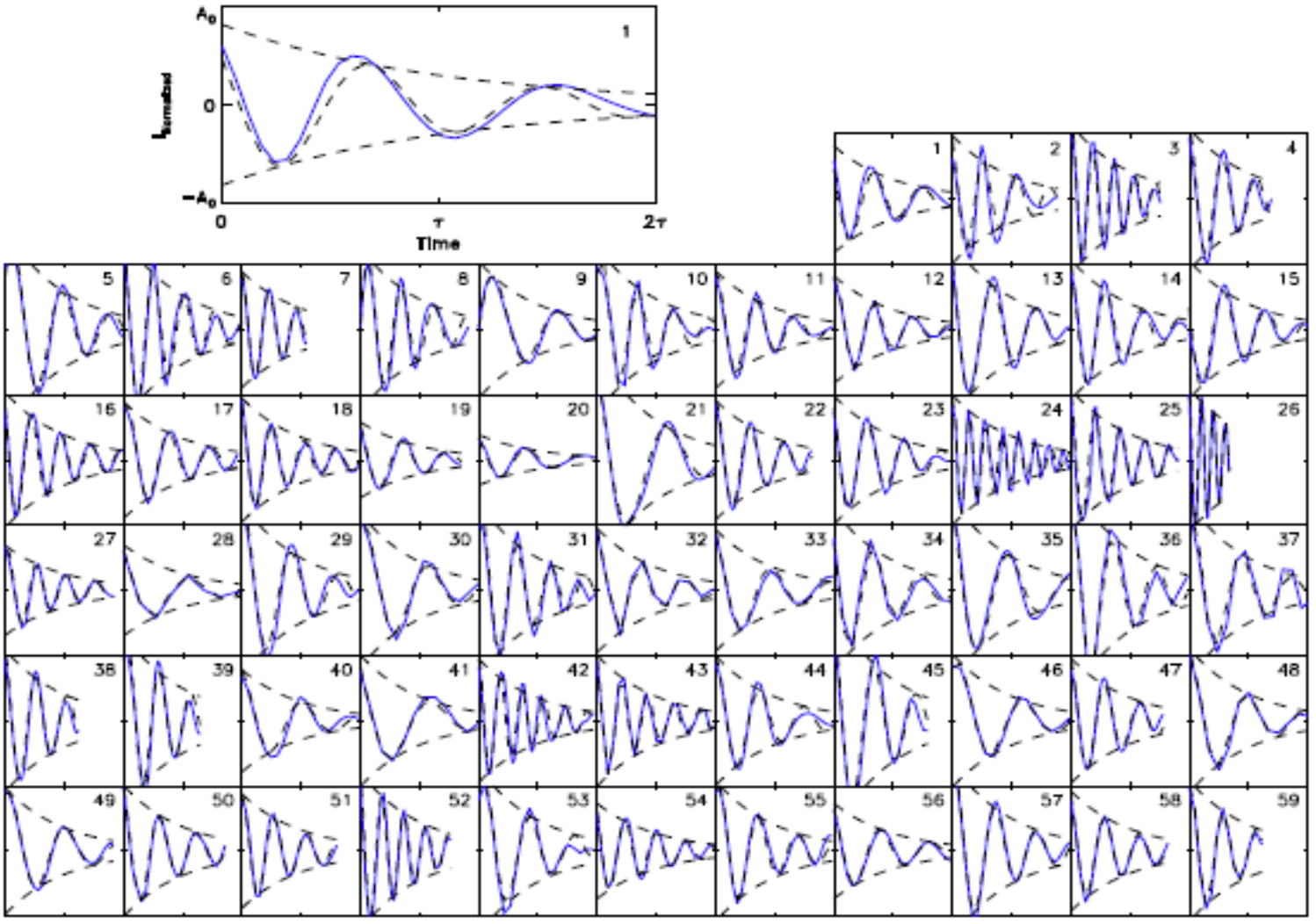
Repeats



IMF Candidate

$Y(t) - IMF_1$

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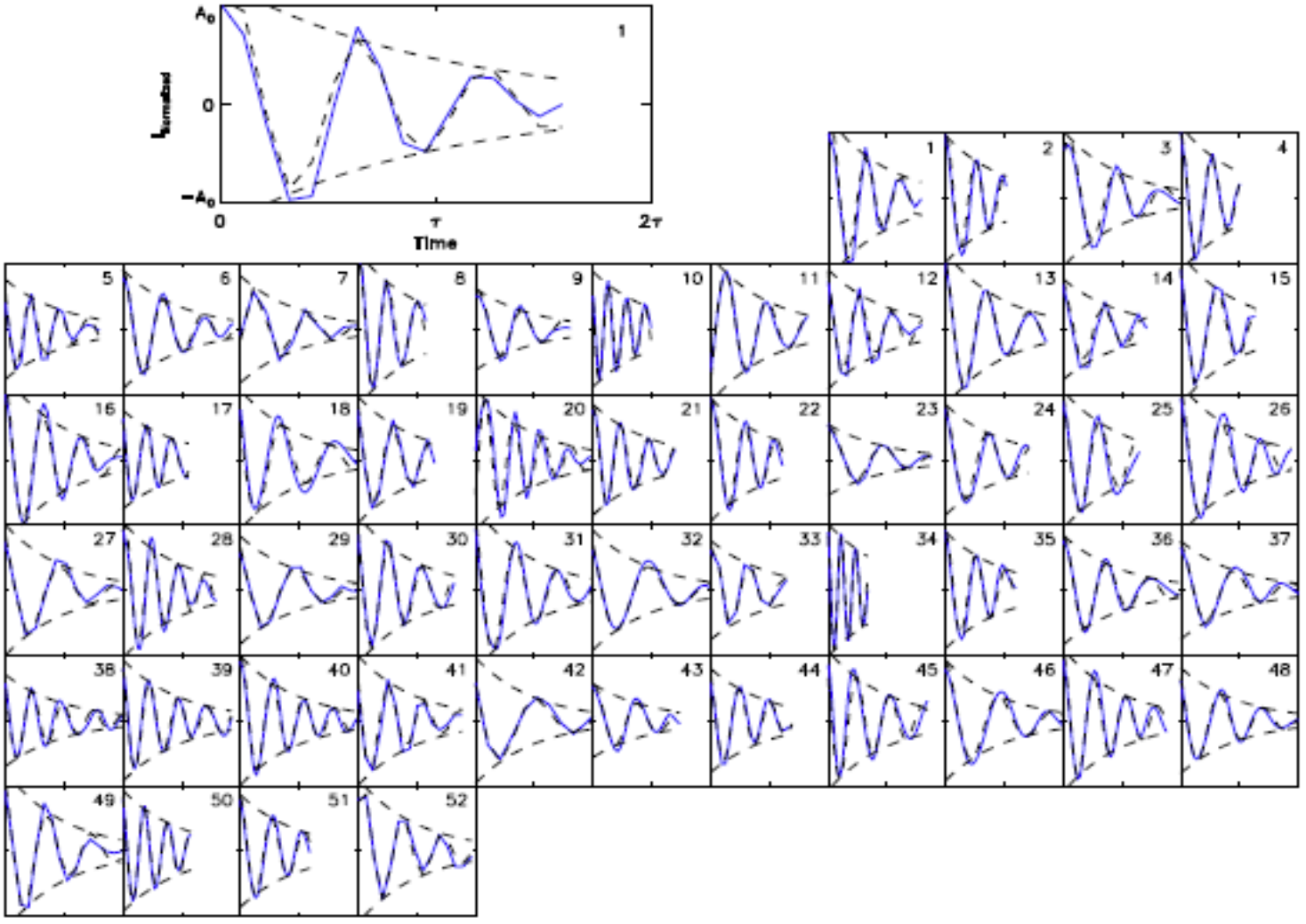
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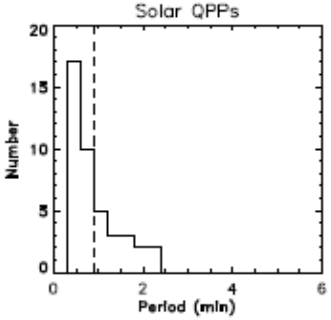
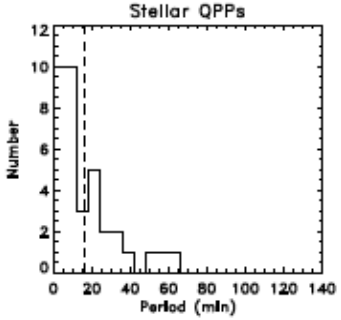
Result – Statistics

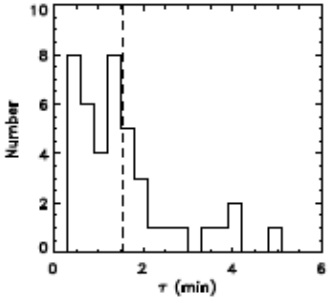
Solar QPPs | Stellar QPPs

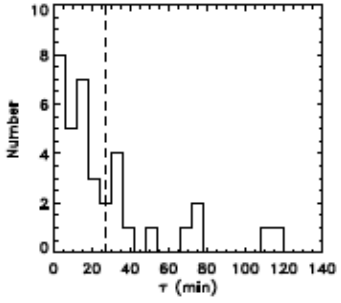
P



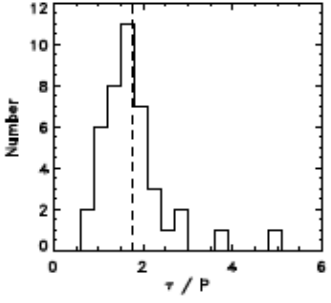


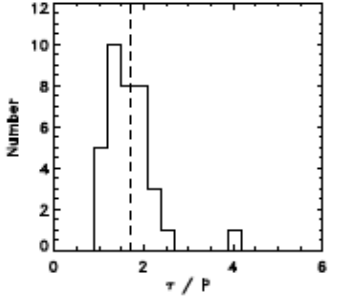
τ





τ/P

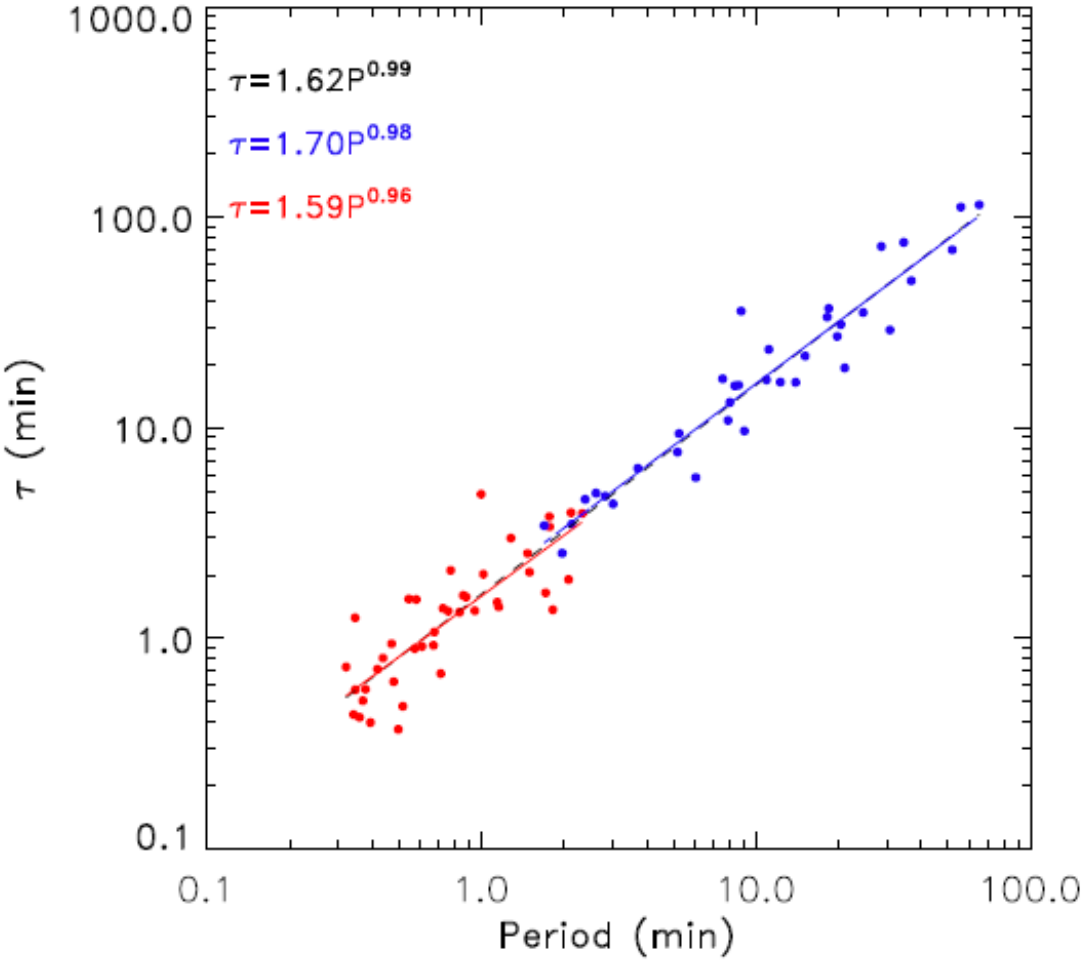




Parameter	Solar QPPs	Stellar QPPs	K-S Test
$P(min)$	0.90 ± 0.56	16.21 ± 15.86	
$\tau(min)$	1.53 ± 1.10	27.21 ± 28.73	
τ/P	1.74 ± 0.77	1.69 ± 0.56	p-value= 0.93^{a}

The period (P) and damping time (τ) of stellar QPPs are quantitatively different from those of solar QPPs, but the **τ/P** in two samples are statistically **identical**.

Result – Scaling



1.17±0.34
(Ofman & Aschwanden et al. 2002)

1.06±0.18
(Wang et al. 2003)

Summary and Discussion

The ratios of the damping time to the period and the power indices of the **soft X-ray QPPs** in the solar and stellar flares are quite similar.

The power indices (0.96 and 0.98) are well consistent with those observed in the SUMER (1.06±0.18, Wang et al. 2003) and TRACE oscillations (1.17±0.34, Ofman & Aschwanden 2002).

Hence, **the thermal QPPs in the stellar flares** are likely natural MHD loop oscillations driven by flares or associated CMEs as in the Sun.

The observed periods of RHESSI thermal QPPs are 0.9 min which are much shorter than those of the SUMER (7-33 min) and TRACE (2-31 min).

: explained by 2nd order slow longitudinal mode or higher temperature

$T_{RHESSI} > T_{SUMER}$ (~ 6 MK)

Thank You For Your Attentions.