

Recent outburst activities within the magnetar class

Francesco Coti Zelati



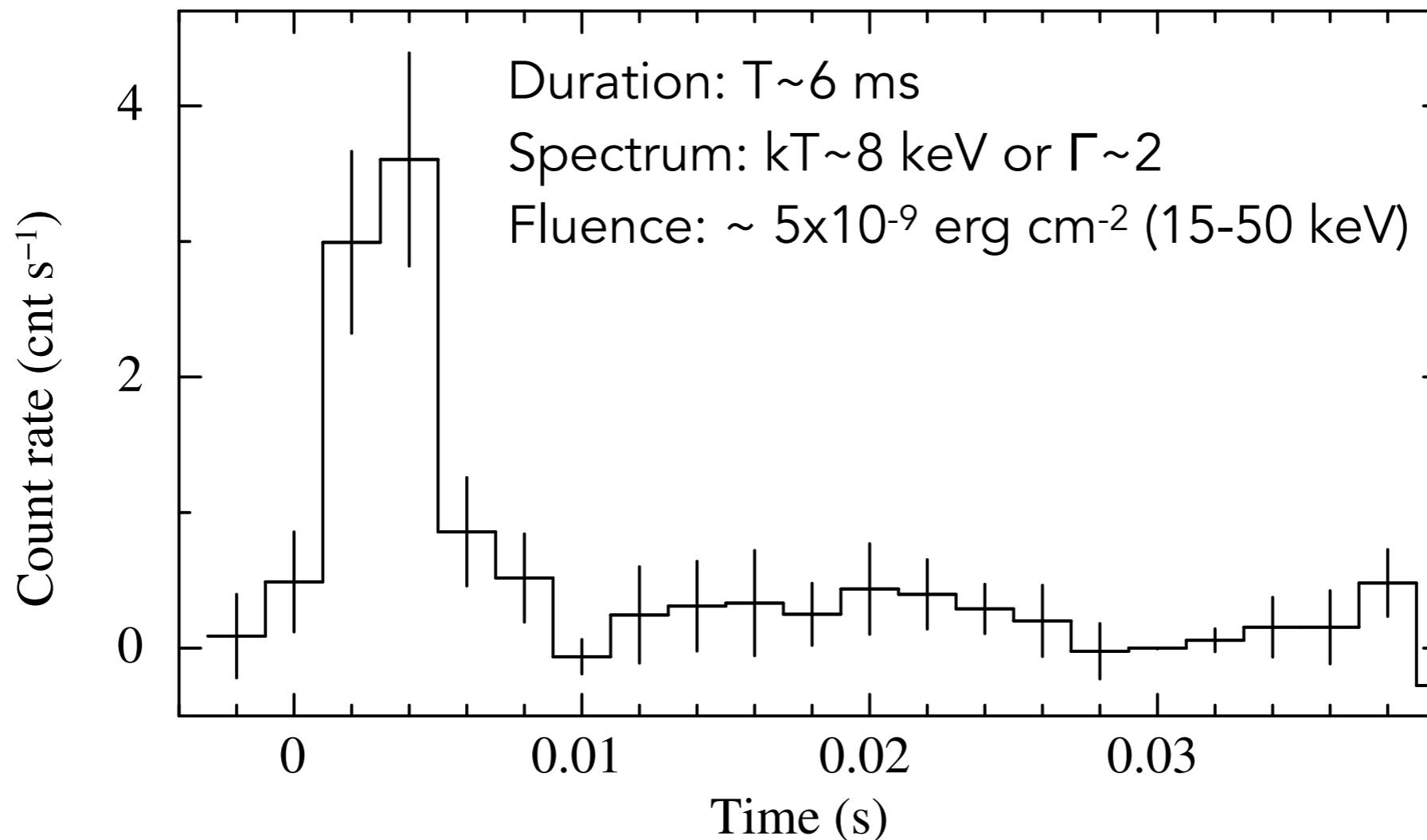
SGR 1830-0645: a new magnetar in outburst

Swift detection of a new SGR 1830-0645 or a short GRB 201010A

ATel #14083; *K. L. Page (U Leicester), S. D. Barthelmy (GSFC), N. J. Klingler (PSU), N. P. M. Kuin (UCL-MSSL) and A. Y. Lien (GSFC/UMBC) report on behalf of the Neil Gehrels Swift Observatory Team*
on 10 Oct 2020; 16:02 UT

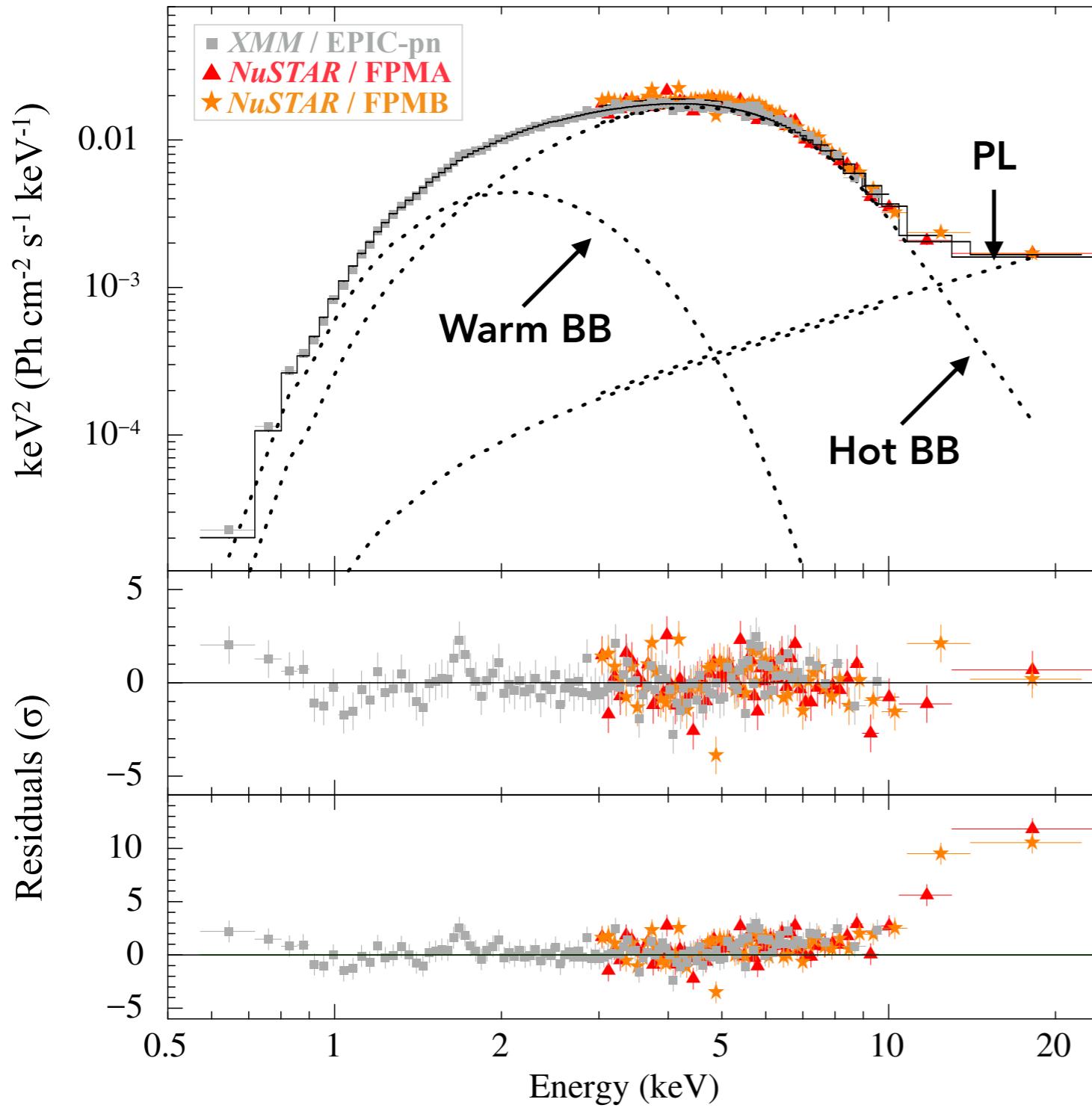
Discovery of the spin period of SGR 1830-0645

ATel #14085; *E. Gogus (Sabanci University), C. Kouveliotou (George Washington University) and G. Younes (George Washington University)*
on 10 Oct 2020; 19:14 UT



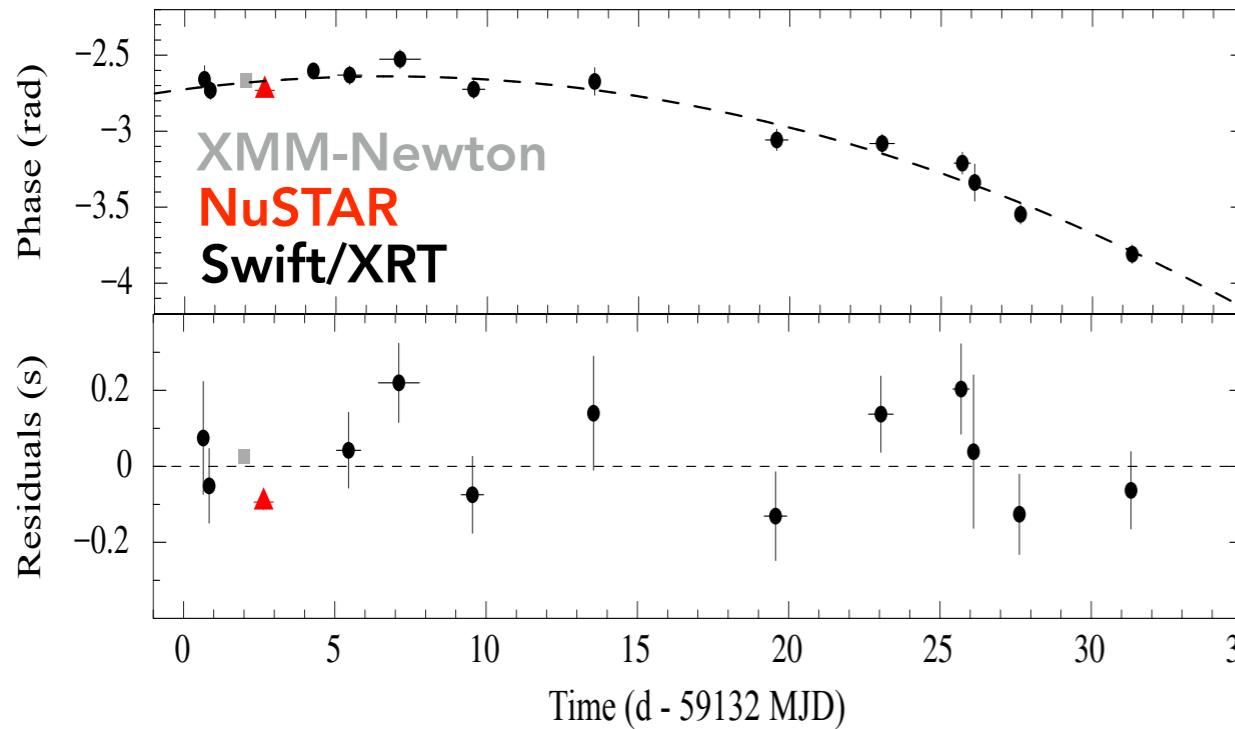
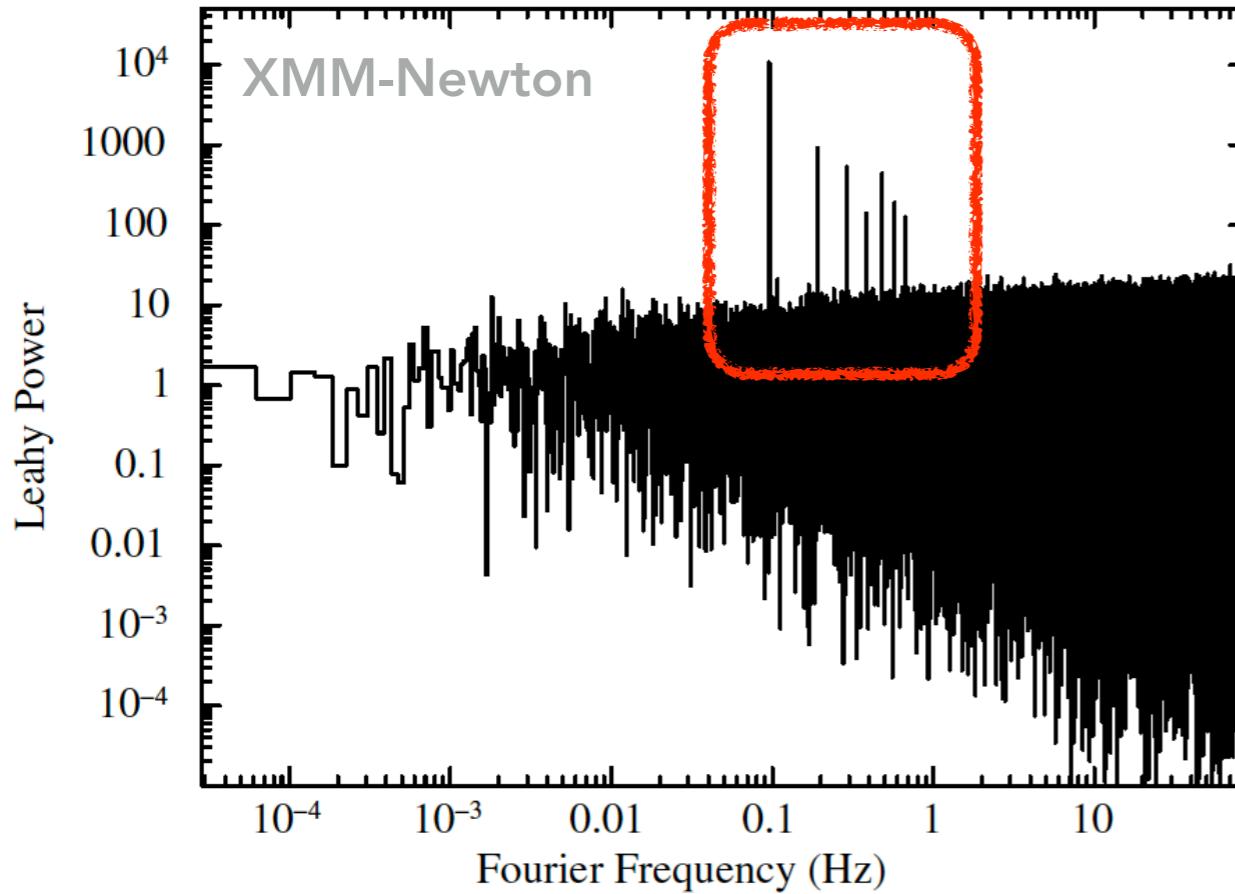
Coti Zelati et al. 2021

Broad-band X-ray spectrum at the outburst peak



- Mostly thermal spectrum plus a faint PL tail (6%).
- Warm BB:
 $kT \sim 0.45 \text{ keV}$, $R \sim 5.6 \text{ km}$ (at 10 kpc)
- Hot BB:
 $kT \sim 1.10 \text{ keV}$, $R \sim 1.5 \text{ km}$ (at 10 kpc)
- Hard power law:
 $\Gamma \sim 1$
- $F \sim 4 \times 10^{-11} \text{ erg s}^{-1} \text{ cm}^{-2}$ (0.3-25 keV), a factor >500 above quiescent limits (ROSAT)

X-ray timing analysis



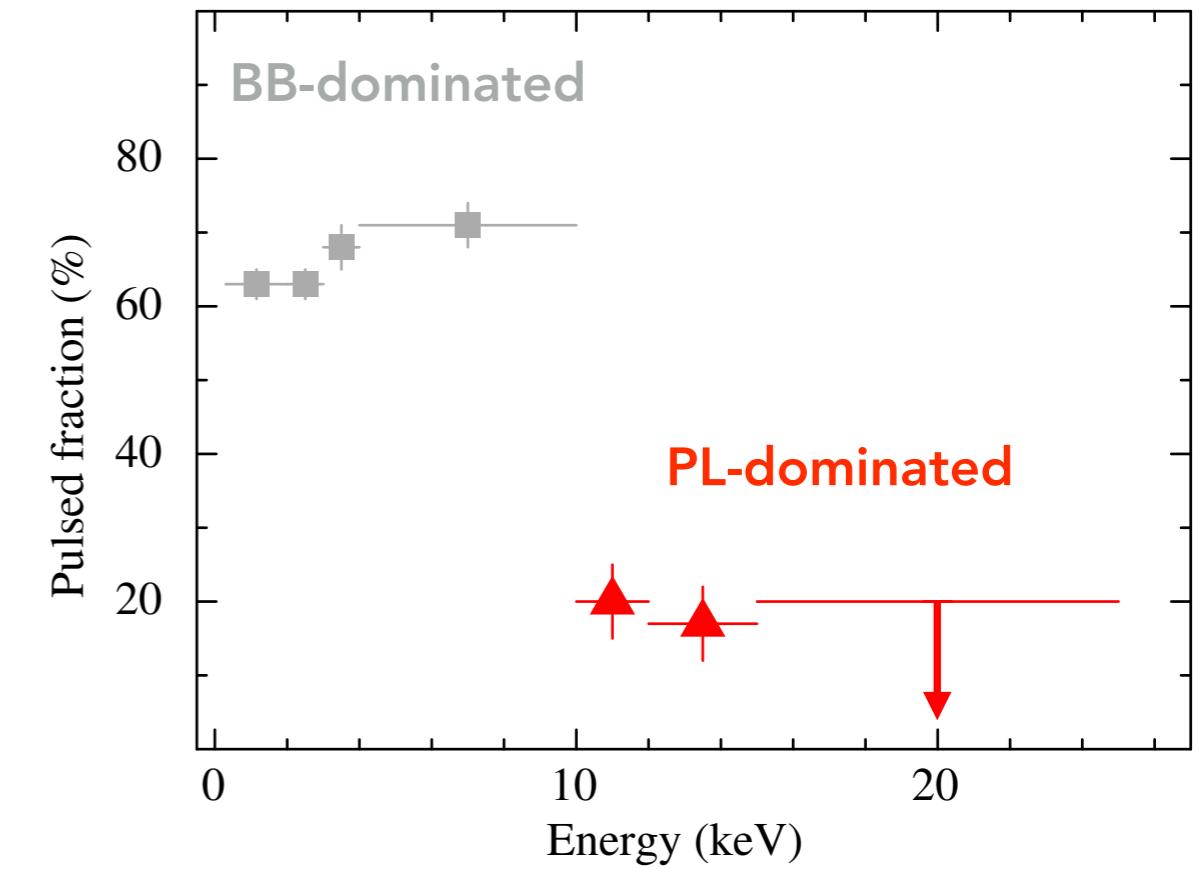
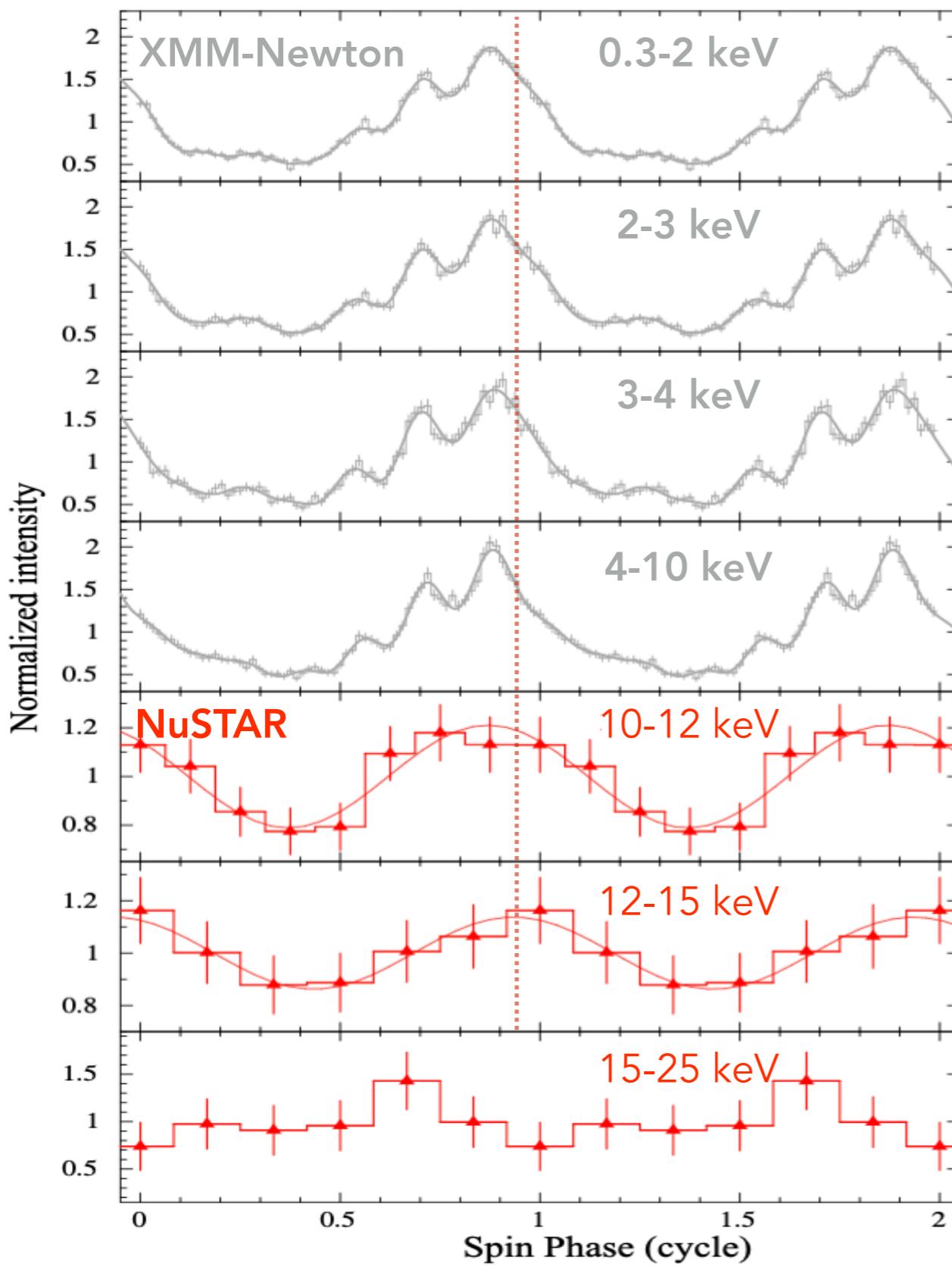
- Power spectrum hints at a complex pulse profile shape

- Phase-connected timing analysis over the first month:
 $P \sim 10.4$ s, $P_{\text{dot}} \sim 7 \times 10^{-12}$ s/s



$B_{\text{dip}} \sim 5.5 \times 10^{14}$ G
 $E_{\text{dot}} \sim 2.4 \times 10^{32}$ erg s⁻¹
 $T_c \sim 24$ kyr

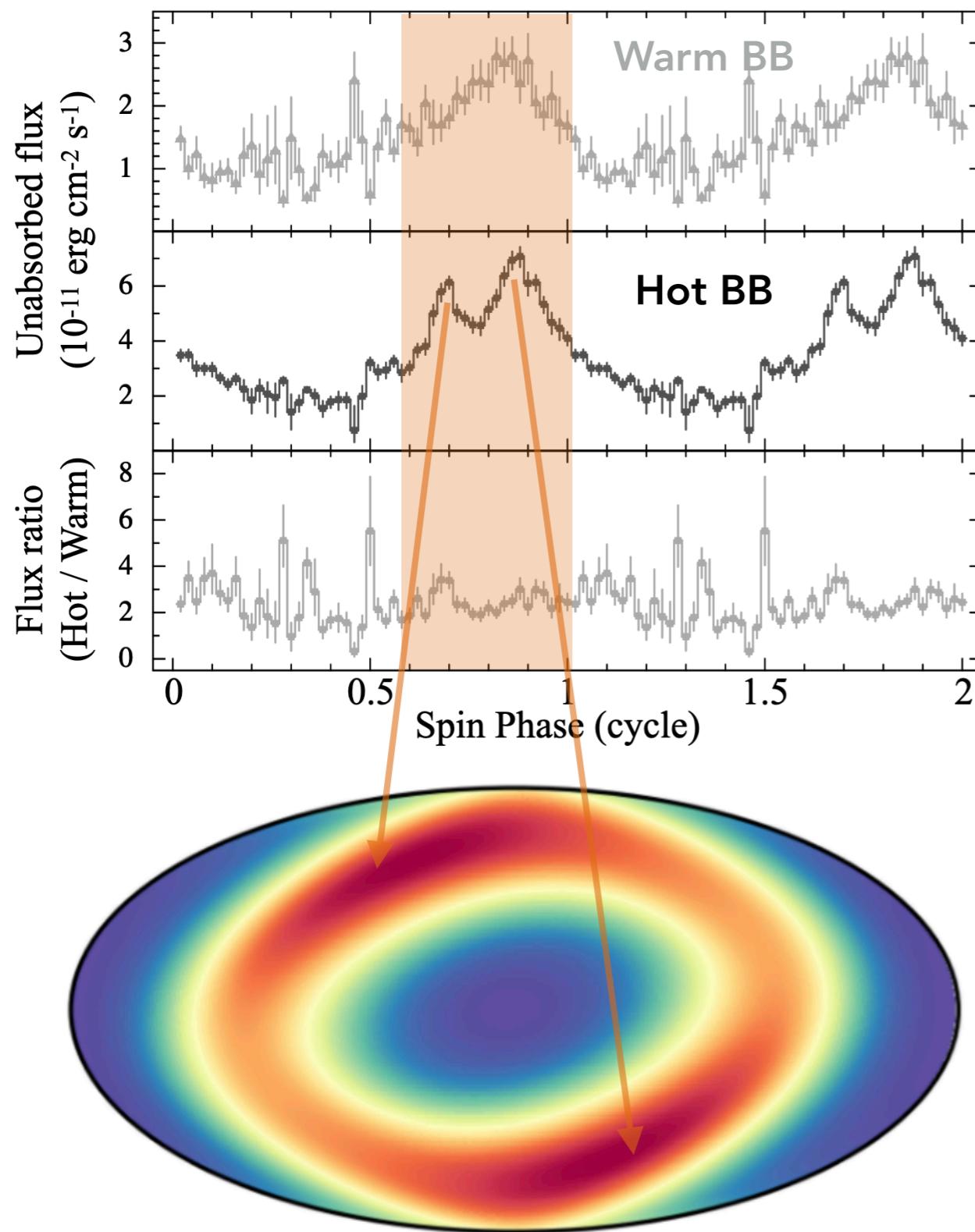
X-ray pulse profiles and pulsed fractions at the outburst peak



- Complex pulse profile shape at low energies. Simpler shape at high energies; slight phase lag
- High pulsed fraction at low energies, dropping above 10 keV —> weakly pulsed non-thermal component

Coti Zelati et al. 2021

Mapping the surface emission: phase-resolved spectral analysis



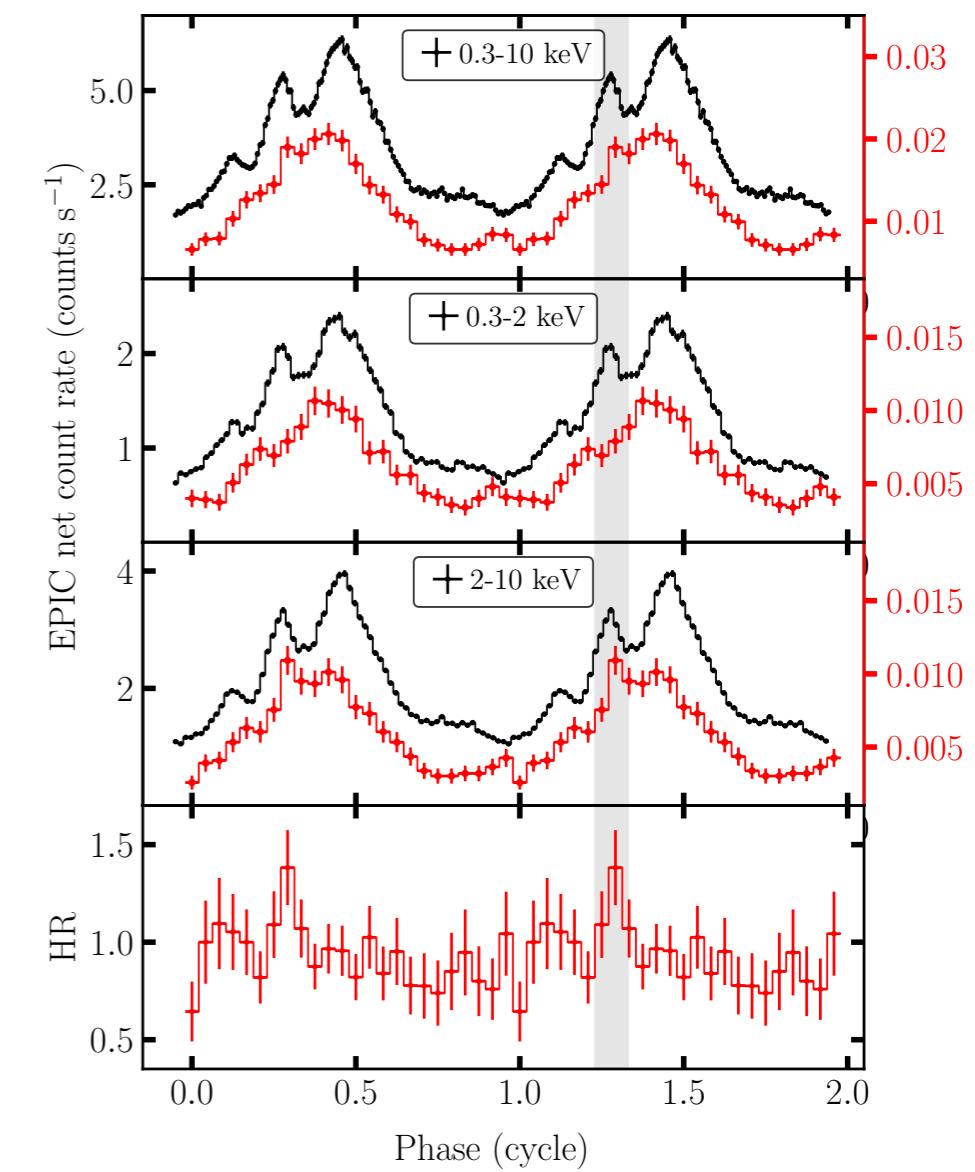
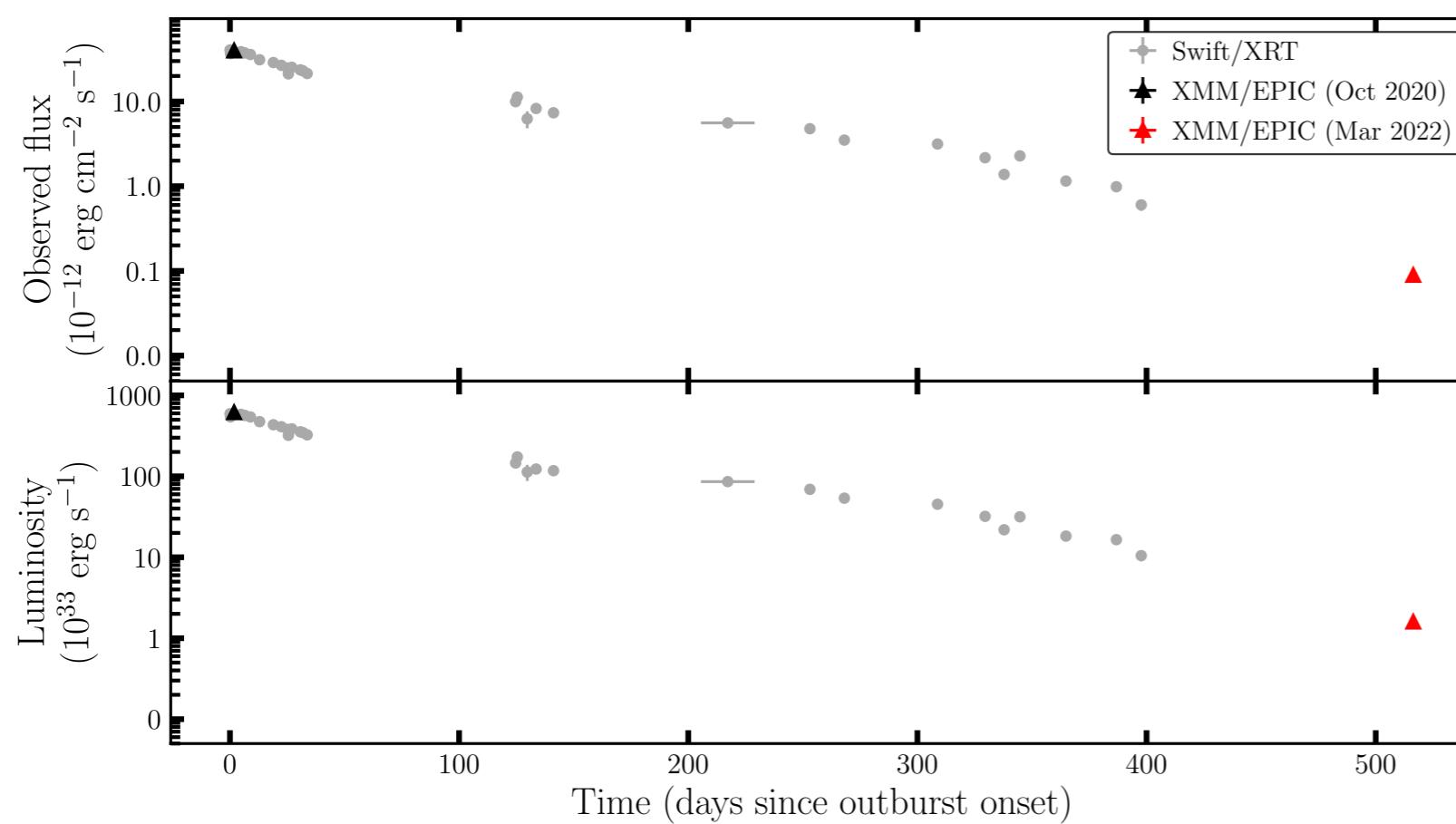
Taken from De Grandis et al. 2021

- Phase-alignment between the BB light curves
- ↓
- Anisotropic heat flow from the crust or returning currents in a twisted bundle (particle bombardment)

See Davide De Grandi's talk

Beloborodov 2009; Pons & Rea 2012;
Turolla, Zane & Watts 2015;
De Grandis et al. 2020, 2022

The long-term evolution



- Intensive monitoring for 1.5 years
- Flux drop by more than three orders of magnitude
- Decay trend in line with that observed in other magnetars
- Remarkable simplification of the pulse profile in time

CZ et al. in prep., Younes et al. 2022a,b

The last discovered magnetar: Swift J1555.2-5402

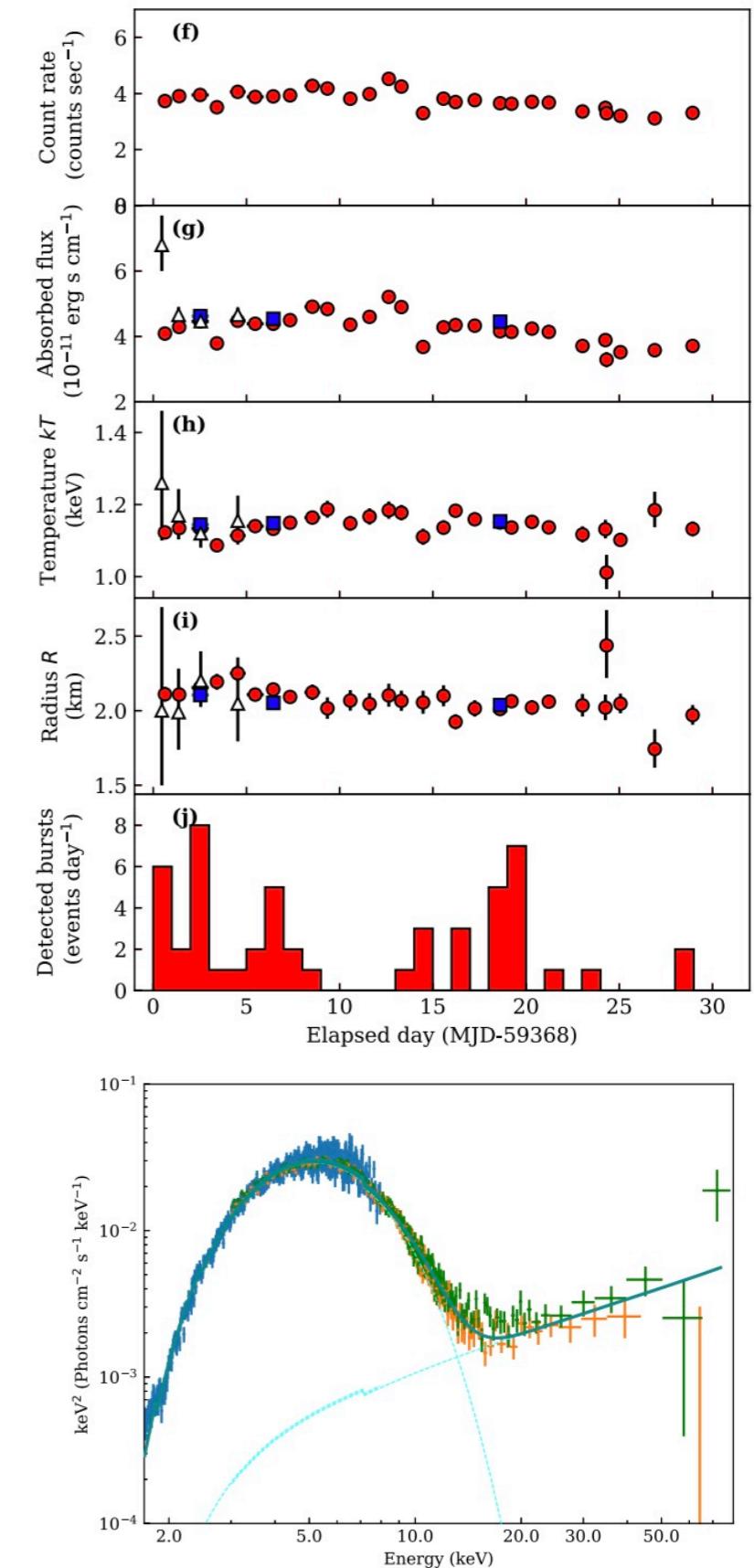
NICER discovery of 3.86 s pulsations from a new magnetar: SGR J1555.2-5402

ATel #14674; **F. Coti Zelati, A. Borghese, N. Rea (ICE-CSIC), G. L. Israel (INAF-OAR), P. Esposito (IUSS Pavia), T. Enoto (RIKEN), K. Gendreau (NASA/GSFC) S. Campana (INAF-OAB) on behalf of a larger collaboration**
on 3 Jun 2021; 16:33 UT

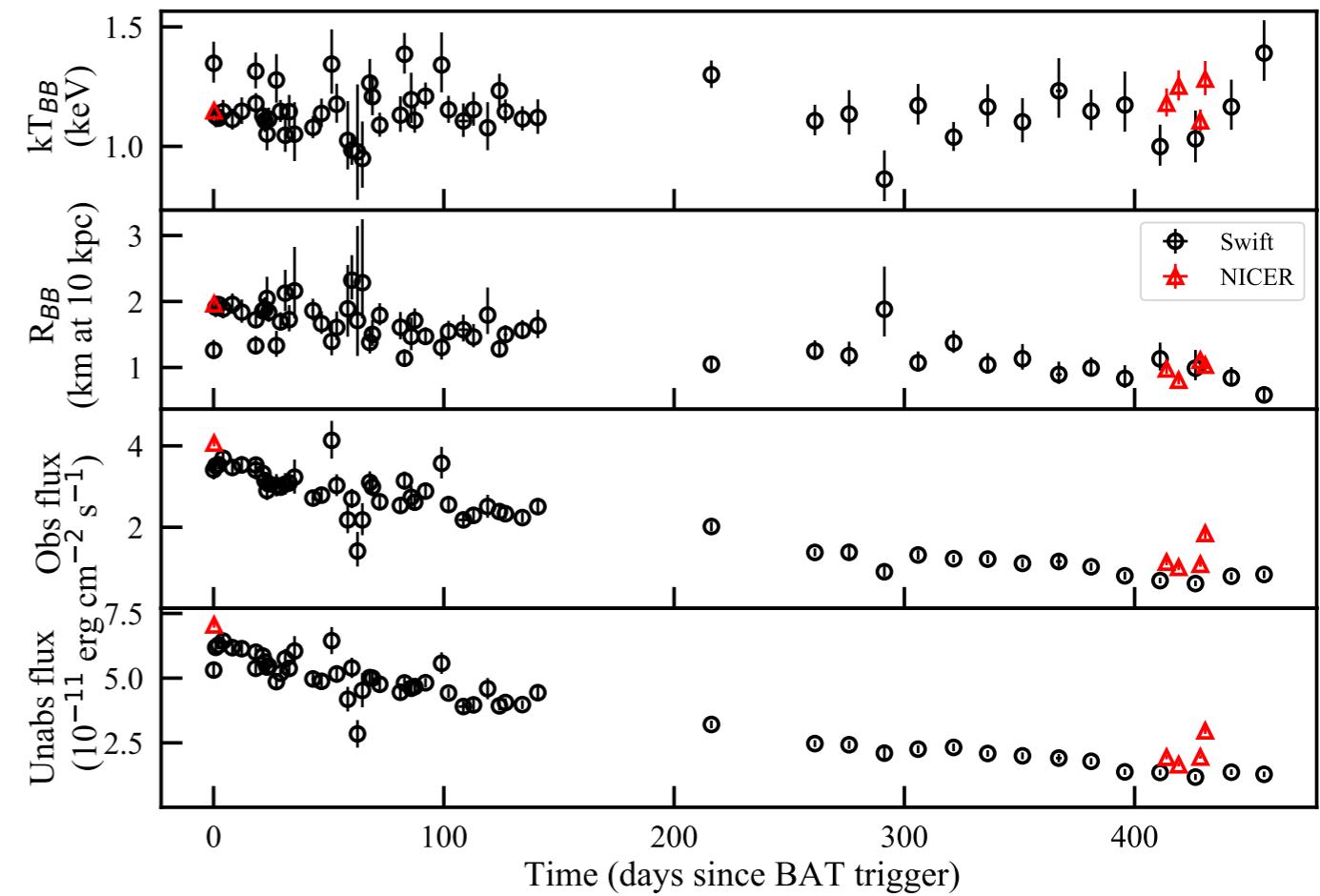
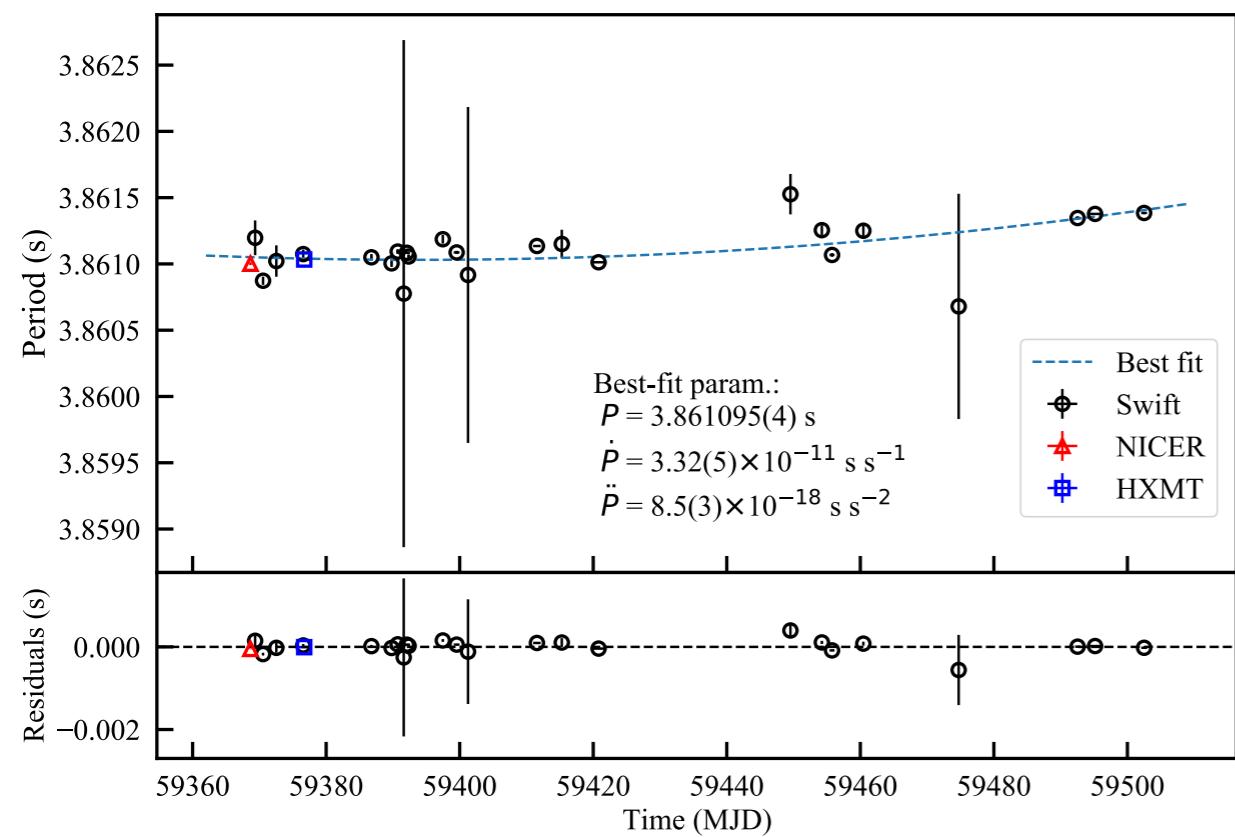
- Daily NICER observations over 1 month.
Thermal spectrum, constant $F \sim 4 \times 10^{-11} \text{ erg s}^{-1} \text{ cm}^{-2}$, several X-ray bursts, $P_{\text{dot}} \sim 3 \times 10^{-11} \text{ s/s}$ (but large timing noise)

$B_{\text{dip}} \sim 3.5 \times 10^{14} \text{ G}$
 $E_{\text{dot}} \sim 2 \times 10^{34} \text{ erg s}^{-1}$
 $T_c \sim 2 \text{ kyr}$

- Emission up to $\sim 40 \text{ keV}$ detected with NuSTAR



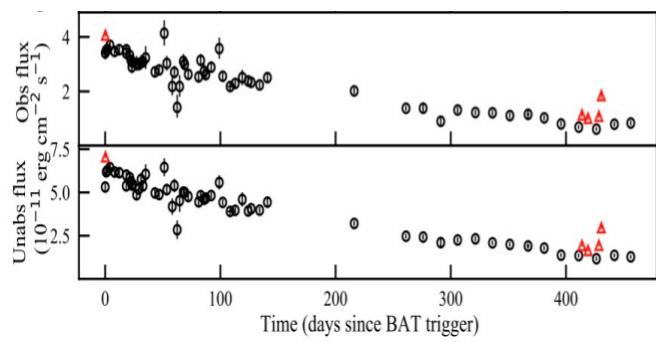
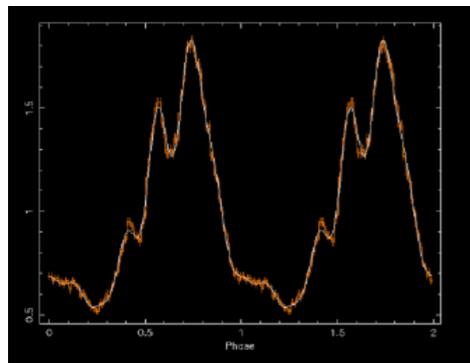
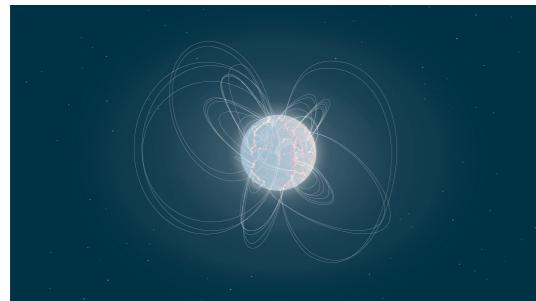
Follow-up observations



- Non-detection of radio pulsations at the outburst peak (Parkes)
- Intensive Swift monitoring over a time span of 15 months and recent NICER campaign
- Marginal variations of the Pdot
- Extremely slow outburst decay probably due to shrinking hot spot(s).
- Current flux much higher than pre-outburst limits. A 1E 1547-5408-like magnetar?

Borghese et al. in prep.

Conclusions and prospects



- SGR 1830-0645 and Swift J1555.2-5402: the two latest additions to the magnetar class
- SGR 1830-0645: mostly thermal spectrum plus a faint non-thermal component at outburst peak. Thermal emission from a single heated region with a complex shape.
- Still currently active. Remarkable simplification of the thermal emission geometry.
- Swift J1555.2-5402: extremely slow outburst decay. Do magnetars hop between different “quiescent states”?
- Ongoing monitoring campaigns

