Accreting Millisecond X-ray Pulsar: X-ray outburst observations
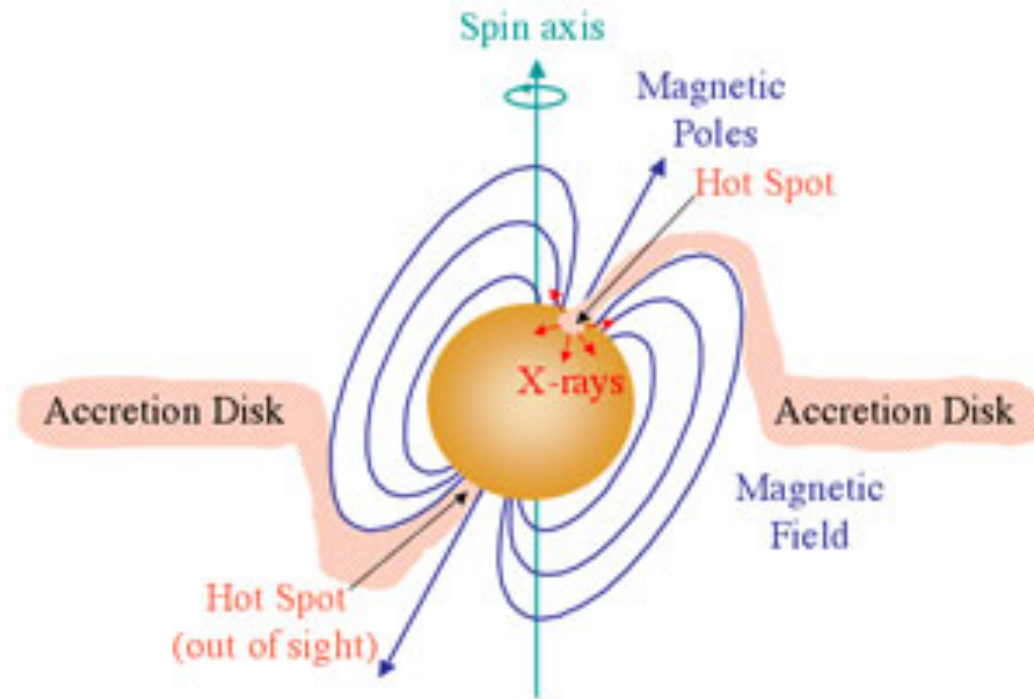
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Outline

- **Accreting millisecond X-ray pulsar**

- **SAX J1748.9-2021**

➢ **X-ray bursts**

➢ **Spectral transition**

- **Swift J1756.9-2508**

➢ **X-ray pulsar profile**

including NICER, NuStar, HXMT…

- **Summary**

Accreting millisecond X-ray pulsar

- **Subgroup of LMXBs**
- **19 AXMPs confirmed**
- **$P_s \sim 1.7 - 9.5$ ms**
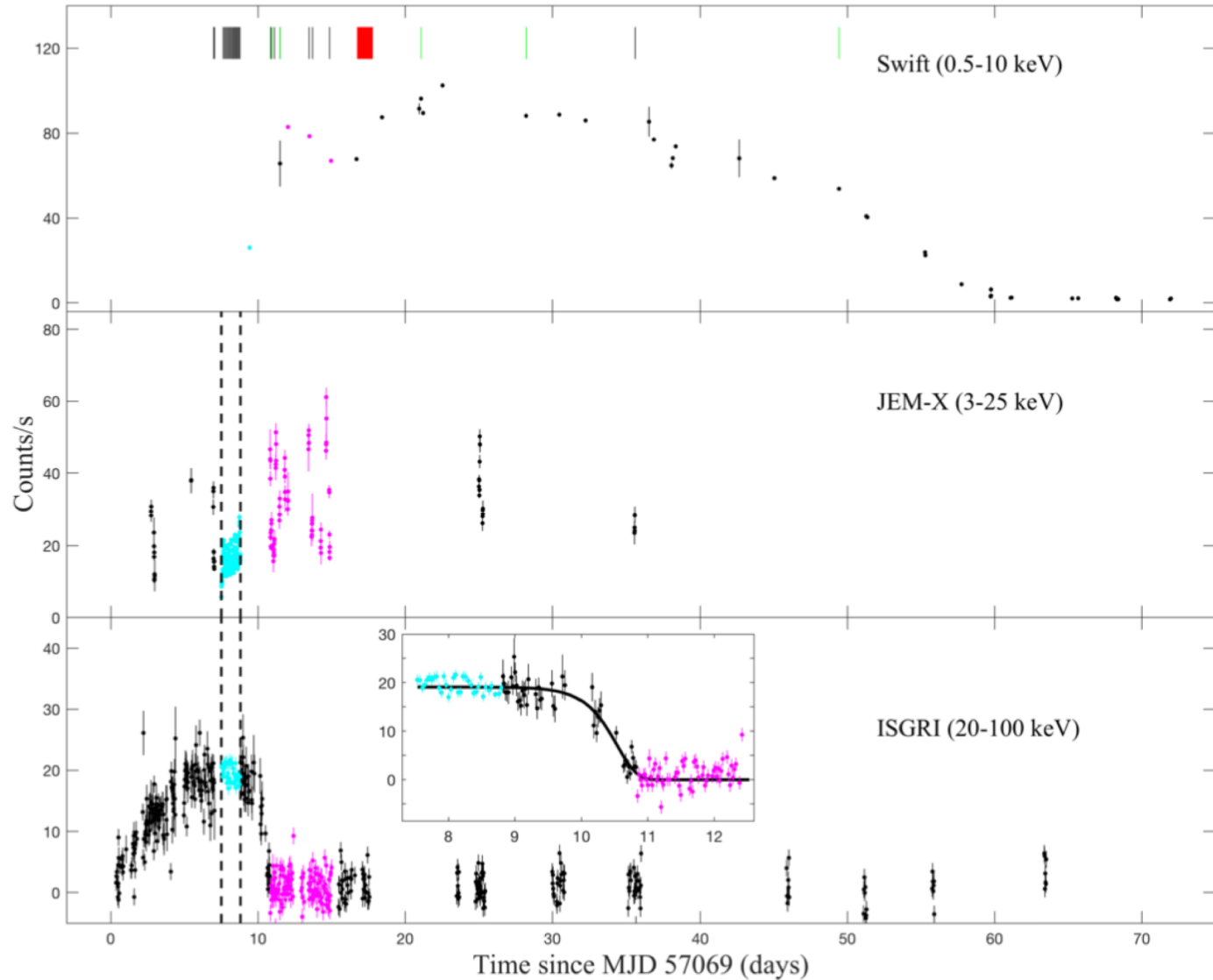- **$P_{orb} \sim 40$ min – 11 hr**
- **recycling scenario**

spin-up, IGR J00291+5934

switch between accretion and rotation power

PSRJ1023+0038, IGR J18245−2452, XSS J12270−4859

SAX J1748.9-2021

- **2015 outburst**

SAX J1748.9-2021

- **Hard-to-Soft transition modeled by compPS**

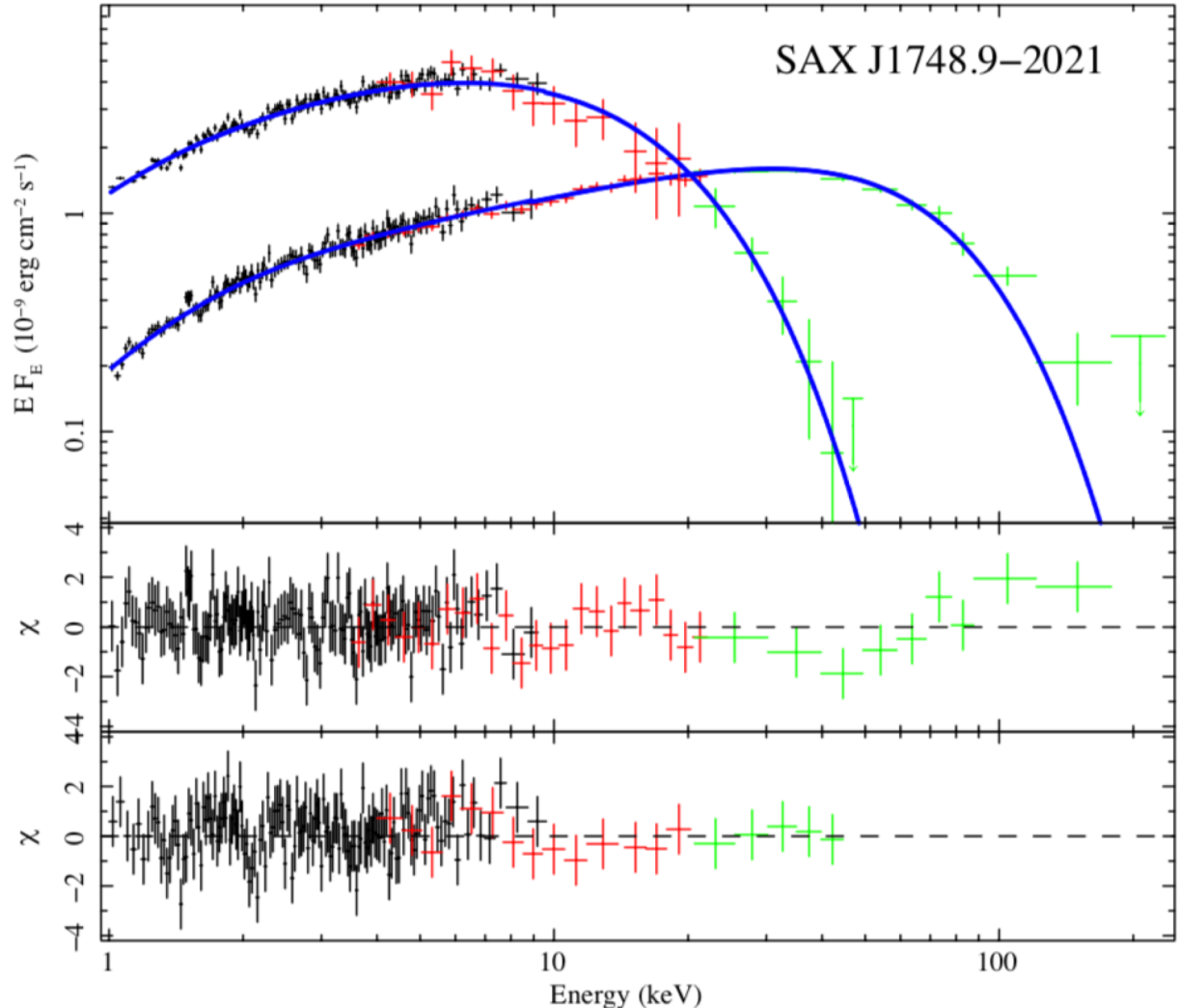- **Soft state**

$kT_{bb, seed} \sim 0.28$ keV
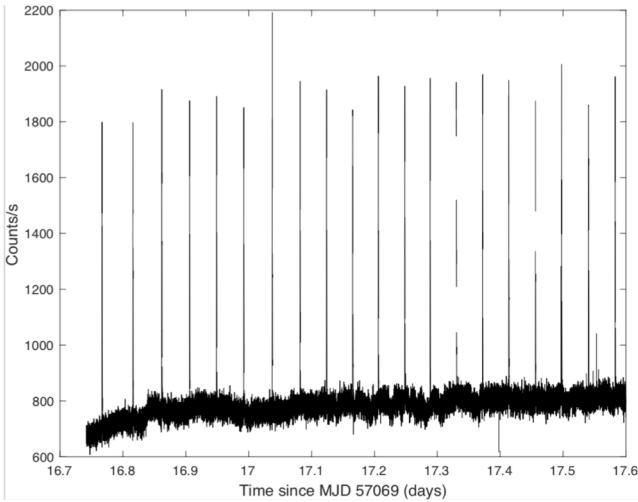$kT_e \sim 5$ keV
$tau \sim 3.8$

- **Hard state**

$kT_{bb, seed} \sim 0.39$ keV
$kT_e \sim 18$ keV
$tau \sim 2.9$

SAX J1748.9-2021: recurrence time

In order to ignite hydrogen and helium a certain pressure and temperature are needed. They are achieved when sufficient amount of fuel has accreted on to the surface.

$$\Delta M = \int_{0}^{T_{rec}} \dot{M}(t)dt \approx$$

$$\left\langle \dot{M} \right\rangle T_{rec} \approx cont \Rightarrow$$

$$T_{rec} \propto \left\langle \dot{M} \right\rangle^{-1} \propto F^{-1}$$

$$\Delta t_{\rm rec} \sim \langle \dot{m} \rangle^{-1.02 \pm 0.03}$$

INTEGRAL/JEM-X bursts/hard state
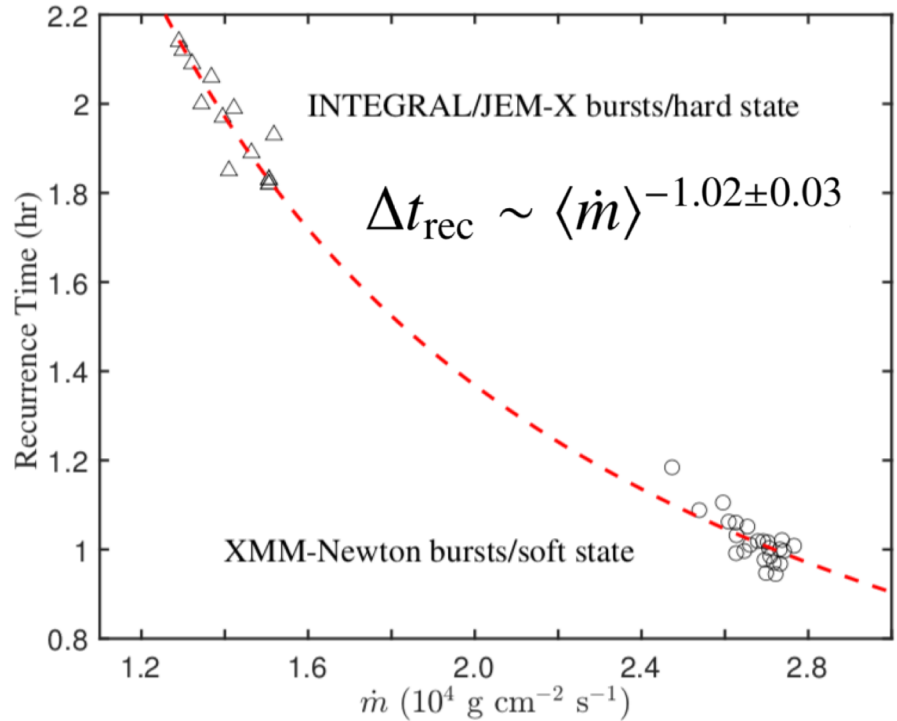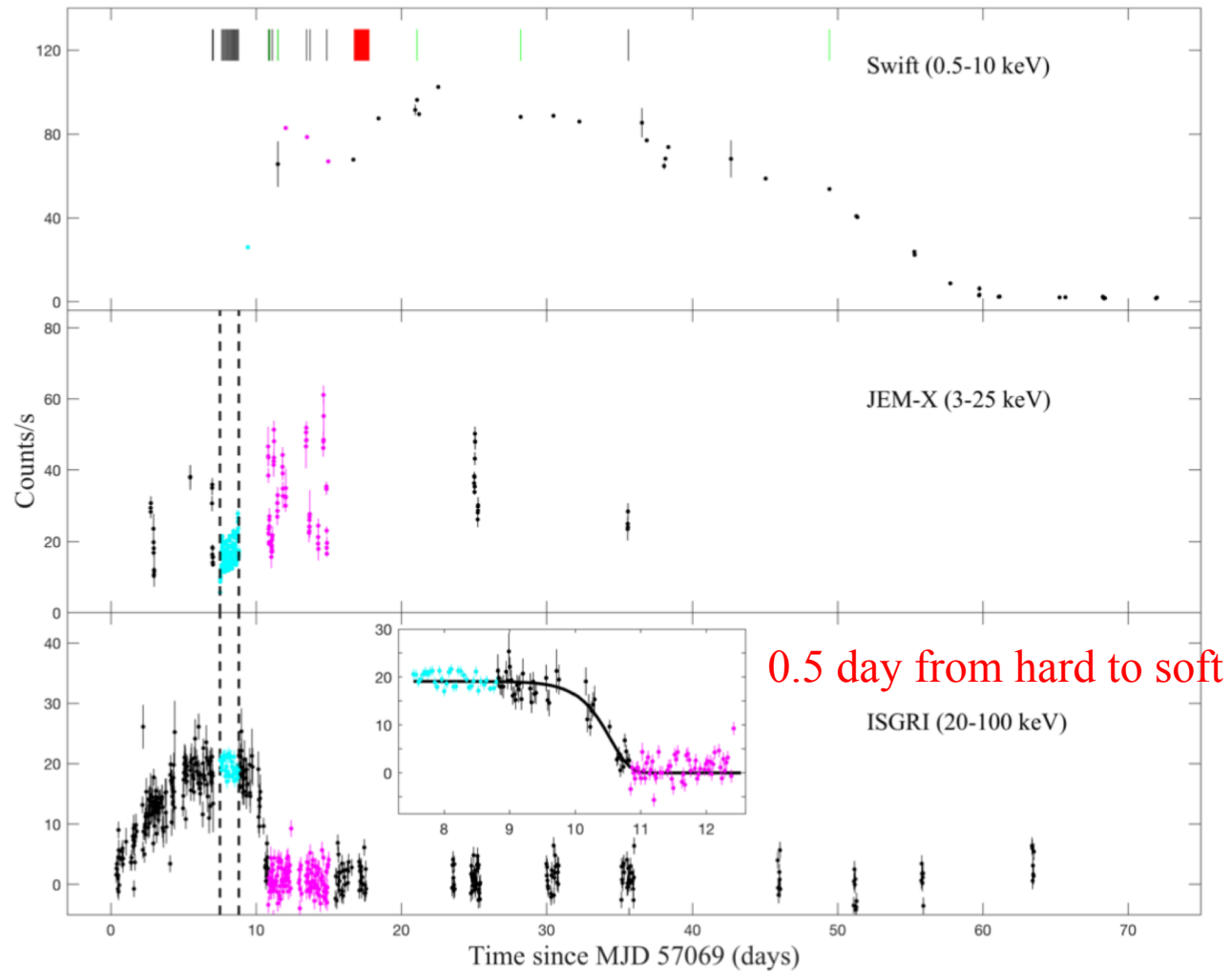
XMM-Newton bursts/soft state

Fig. 4. Recurrence time versus local mass accretion rate per unit area onto the compact object, where the circles and triangles represent the type-I X-ray bursts detected by *XMM-Newton* and INTEGRAL/JEM-X, respectively. The dashed red lines represent the best-fit power-law model for all bursts $\Delta t_{\rm rec} \sim \langle \dot{m} \rangle^{-1.02 \pm 0.03}$. The recurrence time decreased from ~2 h to ~1 h as the persistent spectrum showed the transition from the hard to the soft state.
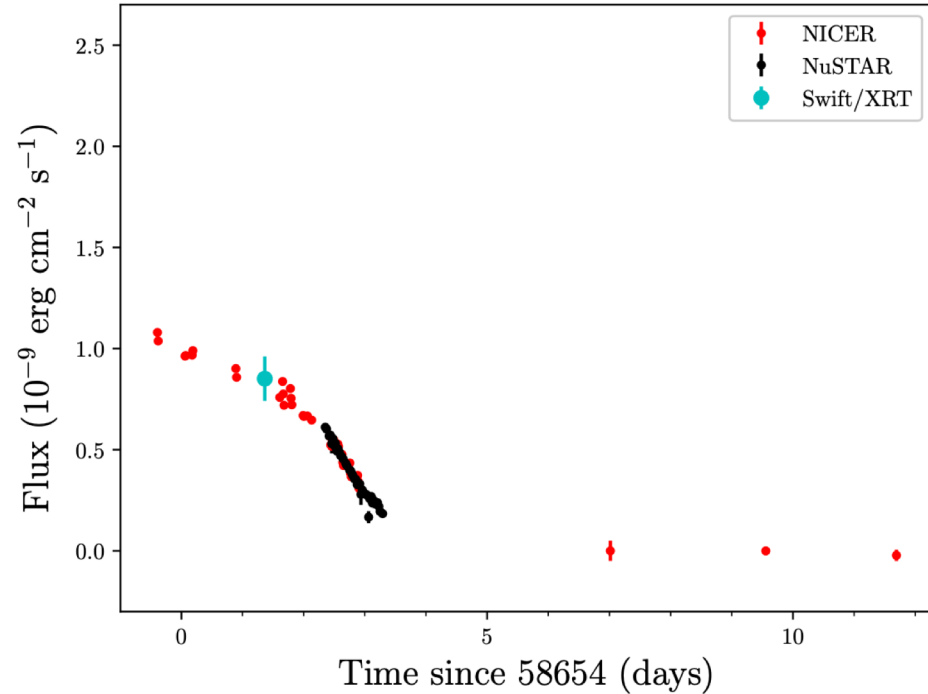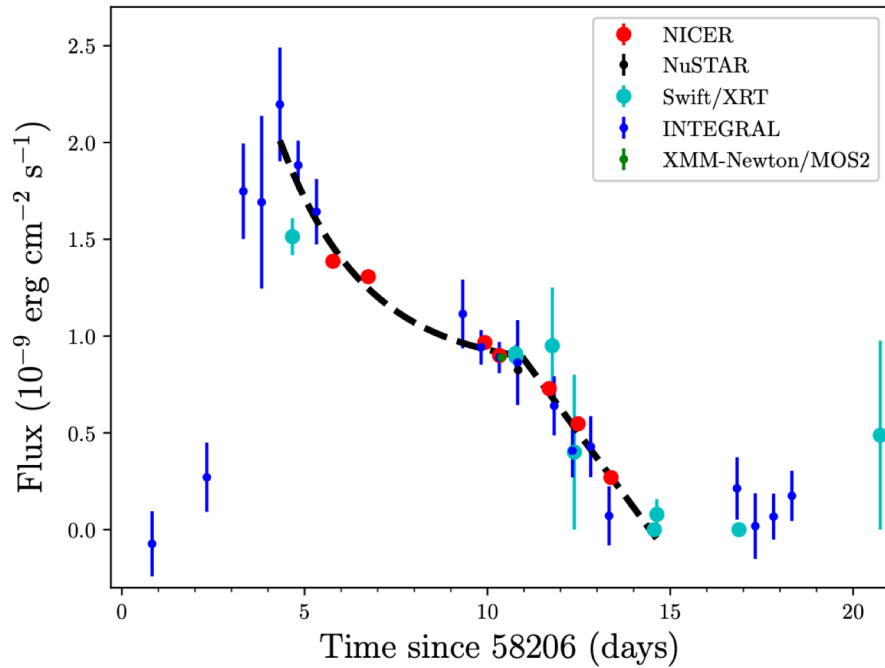
$$\dot{m} = L_{\rm pers}(1+z)(4\pi R^2({\rm GM}/R))^{-1}$$

SAX J1748.9-2021: spectral transition

0.5 day from hard to soft

Li et al. 2018, A&A, A114
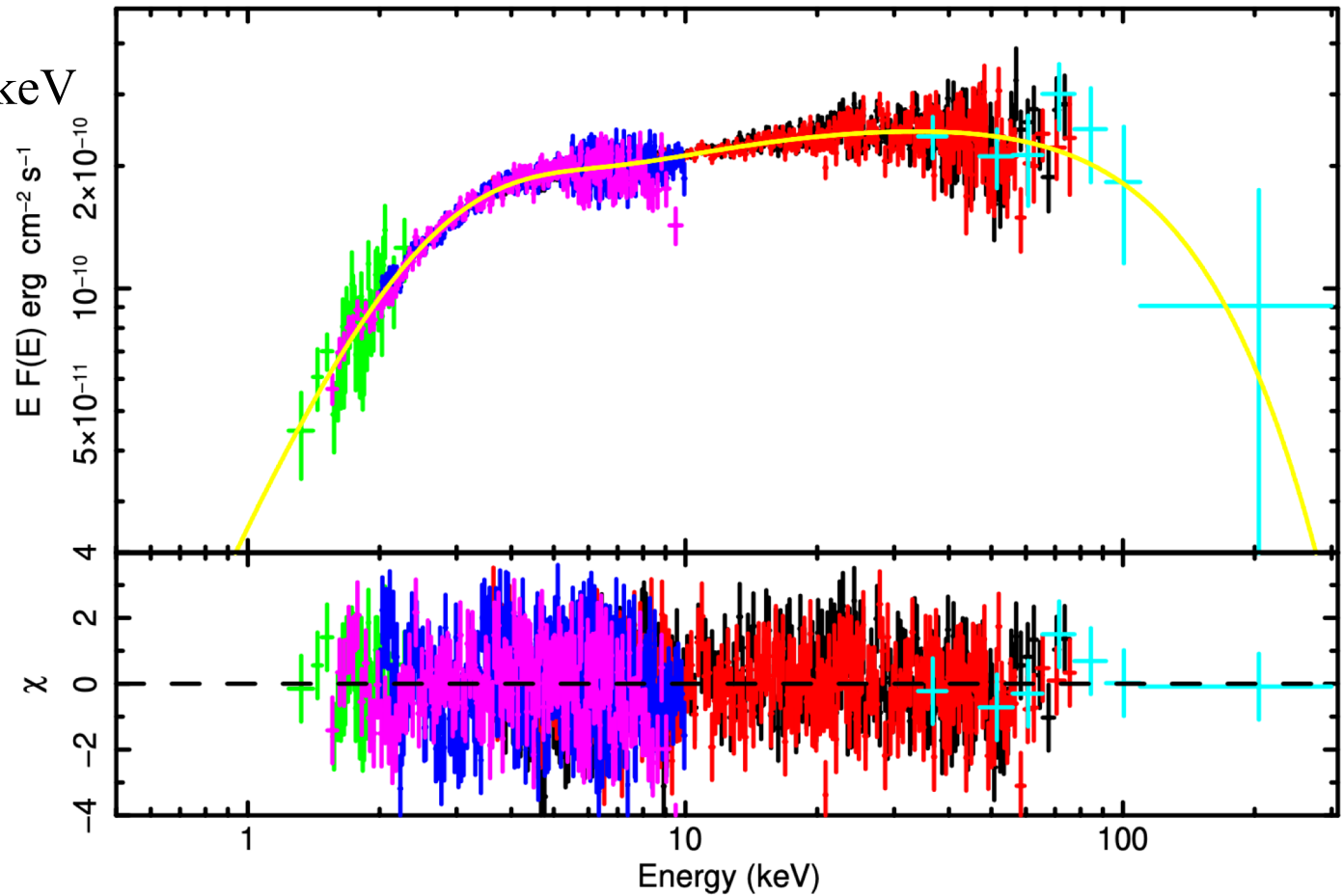
Swift J1756.9-2508

2018 & 2019 outbursts
HXMT observed in 2018

Swift J1756.9-2508

compPS
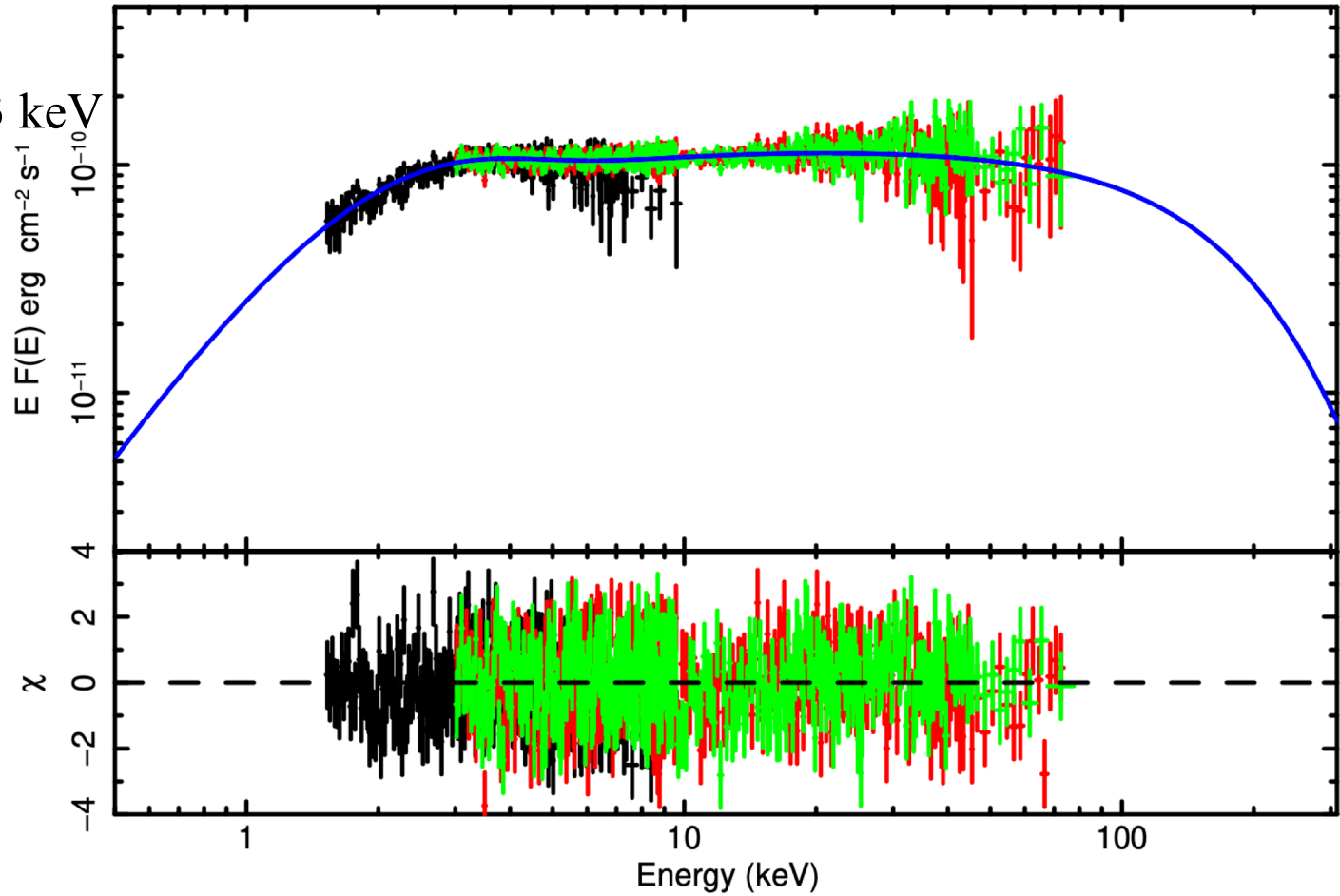$kT_{bb, seed} \sim 0.77$ keV
$kT_e \sim 42$ keV
$tau \sim 1.42$

Swift J1756.9-2508

compPS
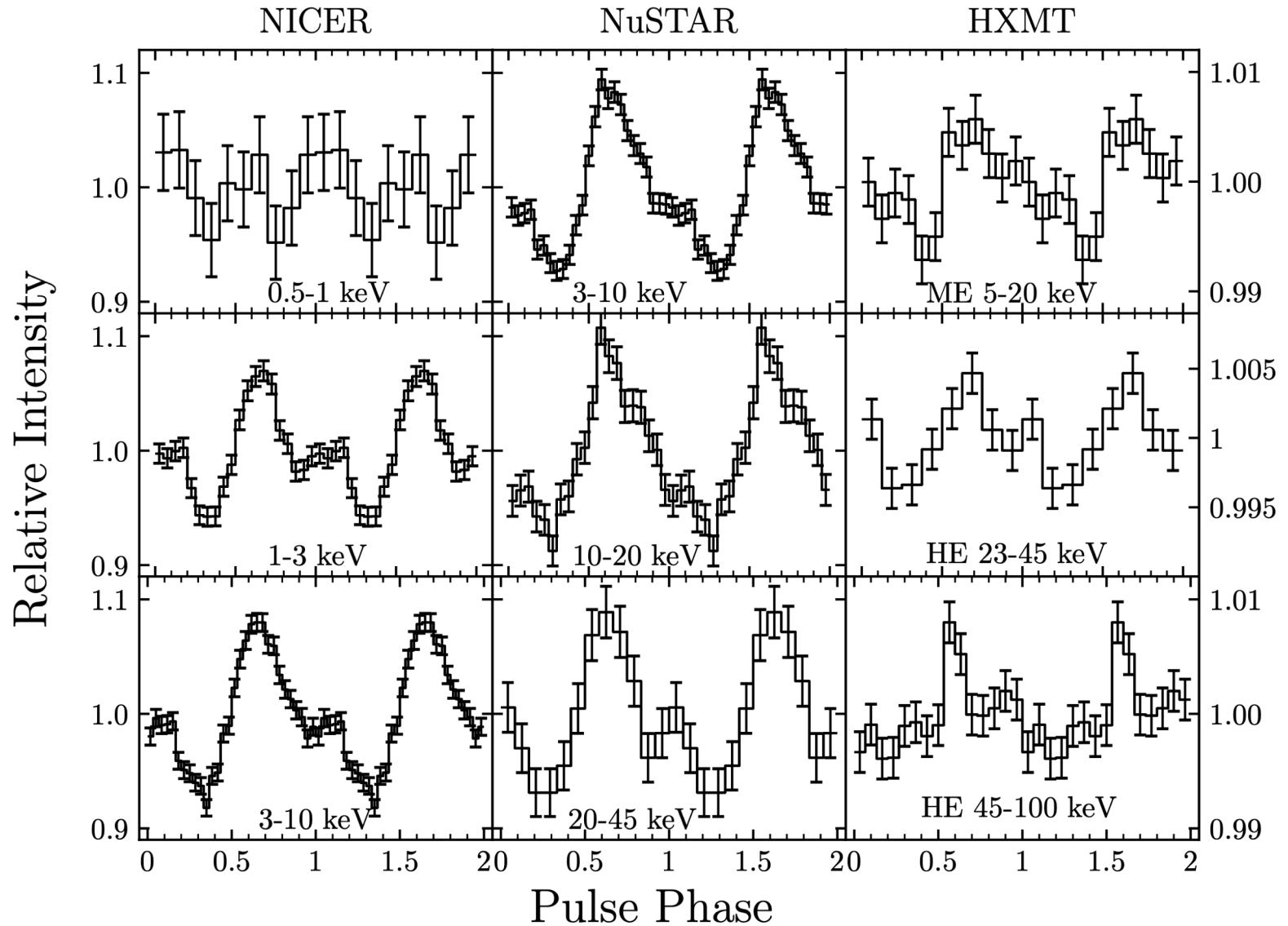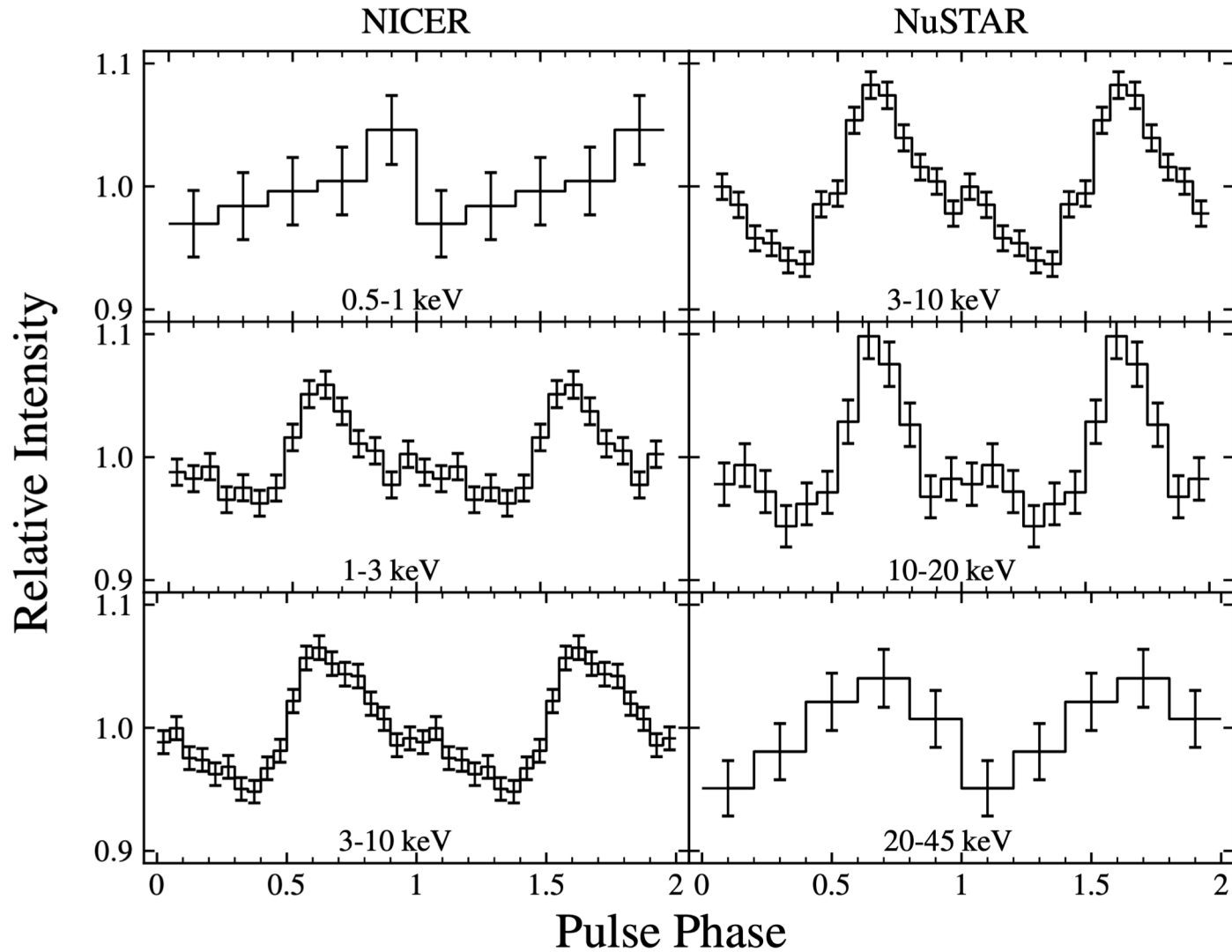$kT_{\mathrm{bb, seed}} \sim 0.63$ keV
$kT_e \sim 47$ keV
$tau \sim 1.59$

Pulse profile-2018 outburst

Pulse profile-2019 outburst

Timing

Table 3. Positional, orbital and rotational parameters derived in this work for Swift J1756.9−2508.

Parameter	Unit	Value
α_{2000}		$17^h\,56^m\,57\overset{s}{.}350$
δ_{2000}		$-25°\,06'\,27\overset{''}{.}80$
$a_x \sin i$	lt-s	0.0059700
e		0
P_{orb}	s	3282.351500
T_{asc}	MJD; TDB	58211.01752500
JPL SS-Ephemeris		DE405
Begin − End	MJD; TDB	58211 − 58666
$\nu^{(c)}$	Hz	182.0658038015293
$\dot{\nu}^{(c)}$	Hz s^{-1}	0

Summary

- **SAX J 1748.9-2021**

H/He bursts

Shortest transition from hard to soft state

X-ray bursts may accelerate the transition

- **Swift J1756.9-2508**

Broad band spectra

Pulse profile