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HXMT views on the accreting millisecond X-ray pulsars

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Outline

- **Recycling scenario**
- **AXMPs**
- **Swift J1756.9-2508 & MAXI J1816-195**
- **Summary & Future**

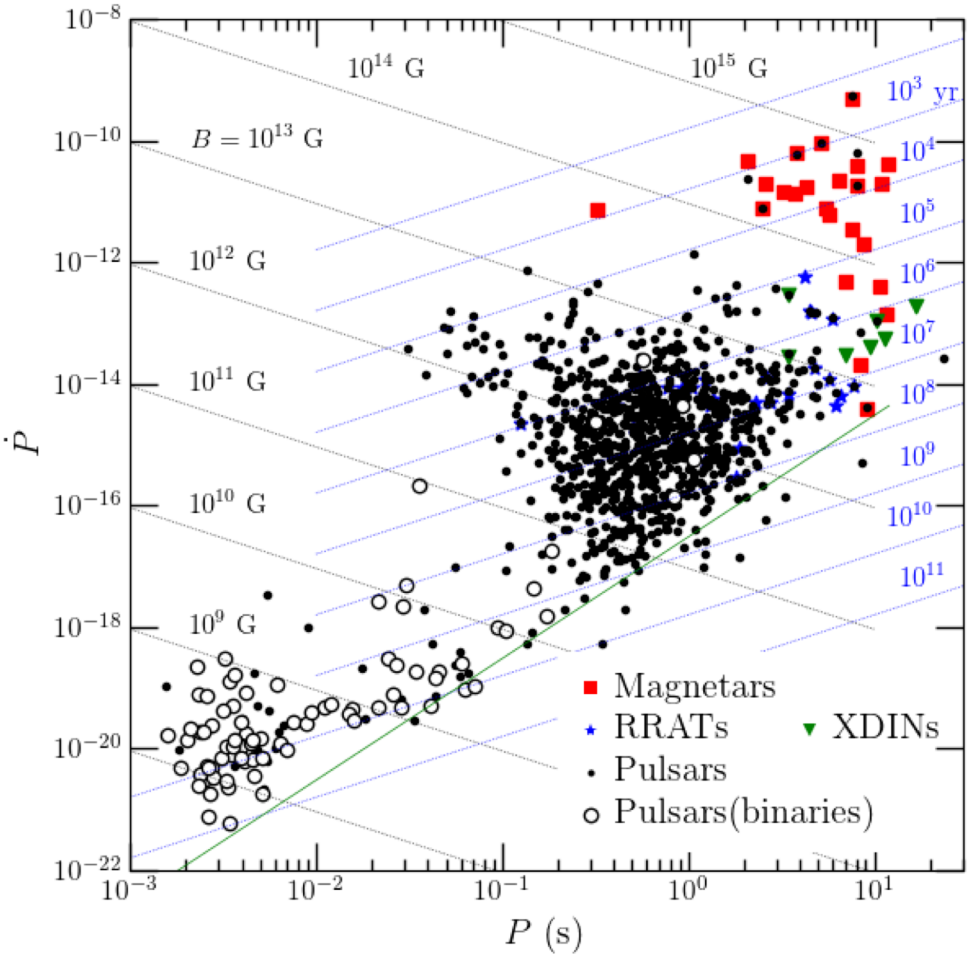
Recycling scenario

- **1982, the first radio millisecond pulsar, PSR B1937+21**

Alpar et al. 1982

Radhakrishnan

& Srinivasan 1982



Recycling scenario

1996, burst oscillation, 4U 1728−34, ~363 Hz

1998, SAX J1808. 4−3658, pulsation, ~401 Hz

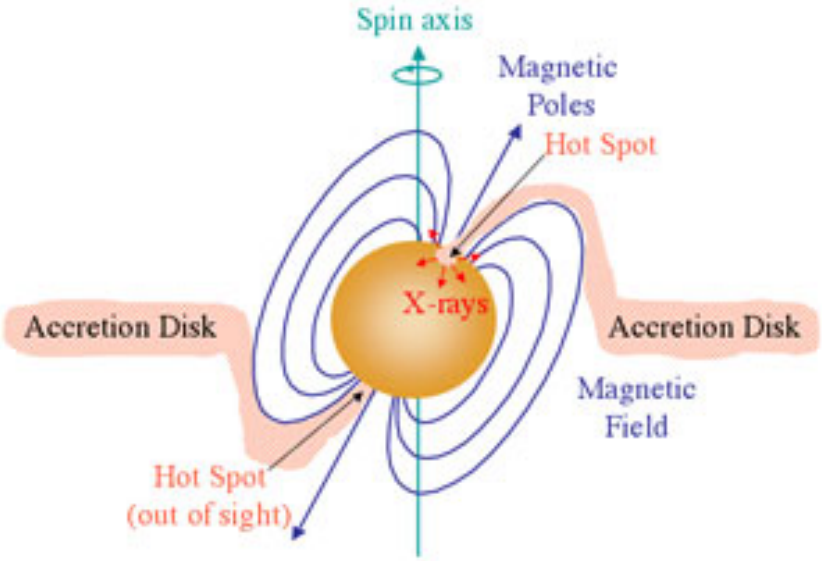
2003, SAX J1808. 4−3658, burst oscillation, ~401 Hz

2005, spin-up, IGR J00291+5934

2013, switch between accretion and rotation power

IGR J18245−2452, PSR J1023+0038, XSS J12270−4859

Accreting millisecond X-ray pulsar



- **Subgroup of LMXBs**
- **23 AXMPs confirmed**
- **Ps ~ 1.7 – 9.5 ms**
- **Porb ~ 40 min – 11 hr**
- **Four AMXPs observed by HXMT**

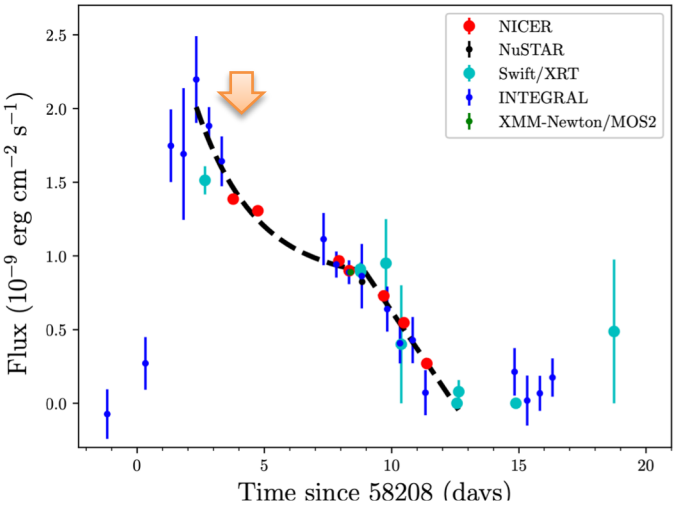
Swift J1756.9-2508 & MAXI J1816-195

SAX J1808.4-3658 & IGR J17498-2921

X-ray pulsation: Swift J1756.9-2508

2018 & 2019 outbursts

HXMT observed in 2018



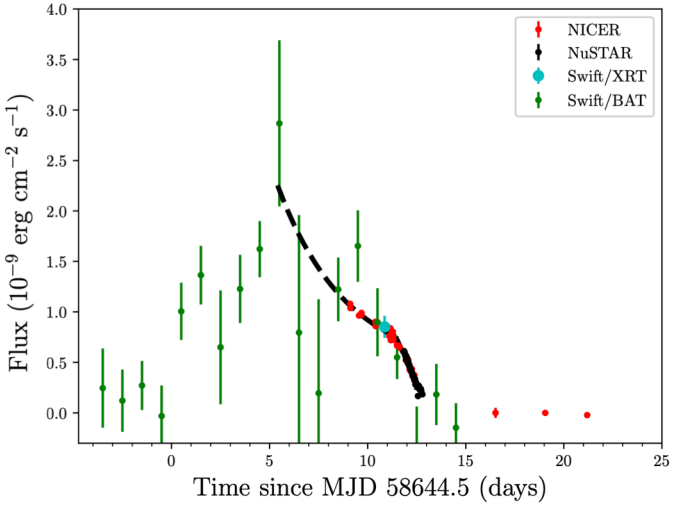
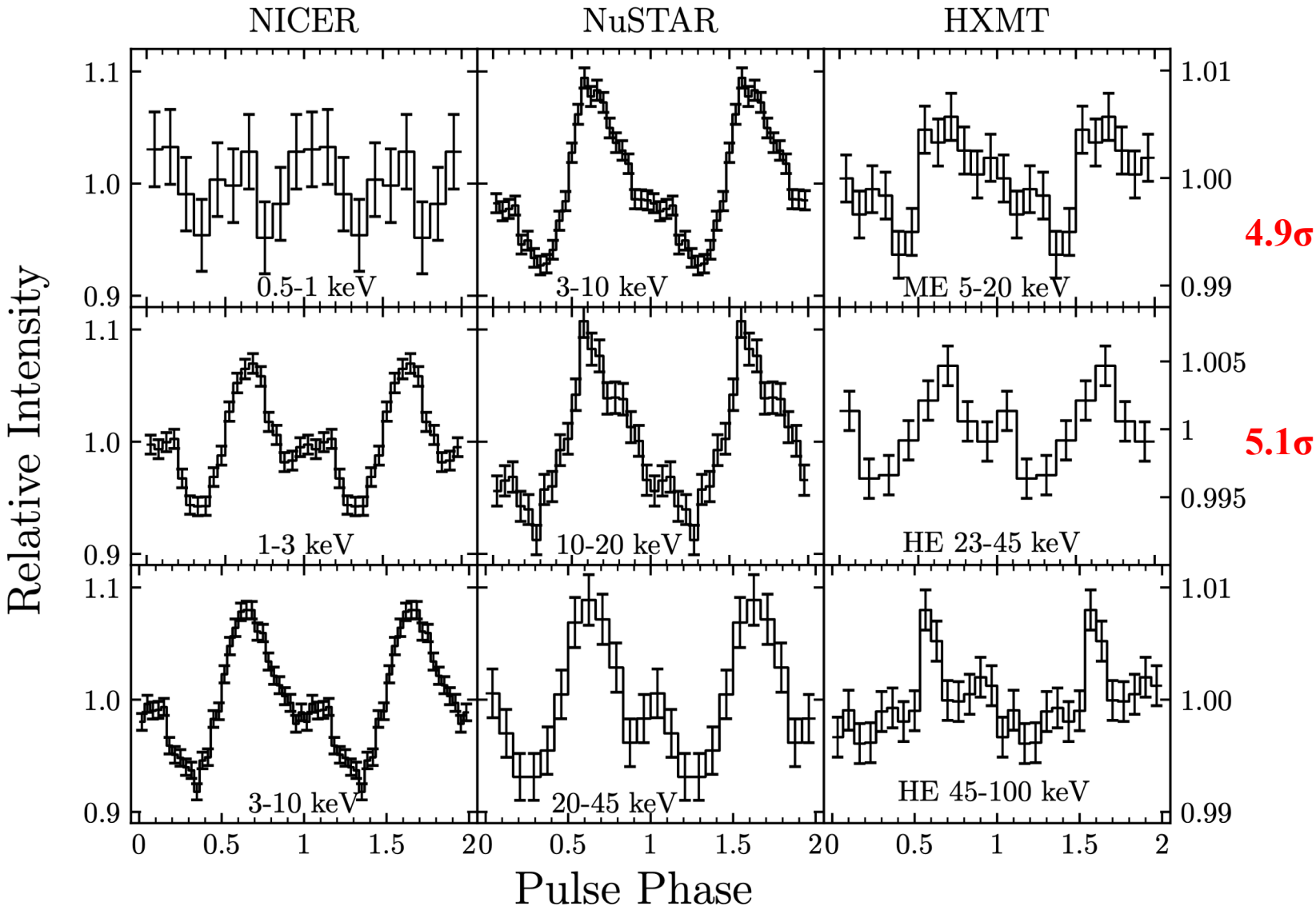


Table 3. Positional, rotational, and orbital parameters used from other works and derived in this work for Swift J1756.9–2508.

Parameter	Units	Values
α_{2000}		$17^{h}56^{m}57\overset{s}{.}350$
δ_{2000}		$-25°06'27\overset{''}{.}80$
JPL Ephemeris		DE405
P_{orb}	s	3282.3515
$a_x \sin i$	lt-s	0.00597
e		0.00
	Outburst – 2018	
ν	Hz	182.065 803 84(3)
Epoch, t_0	MJD; TDB	58216.0
Validity range	MJD; TDB	58211–58219
$T_{asc,2018}$	MJD; TDB	58211.017 52(6)
	Outburst – 2019	
ν	Hz	182.065 803 4(2)
Epoch, t_0	MJD; TDB	58654.0
Validity range	MJD; TDB	58653–58657
$T_{asc,2019}$	MJD; TDB	58655.996 57(12)

Pulse profile-2018 outburst

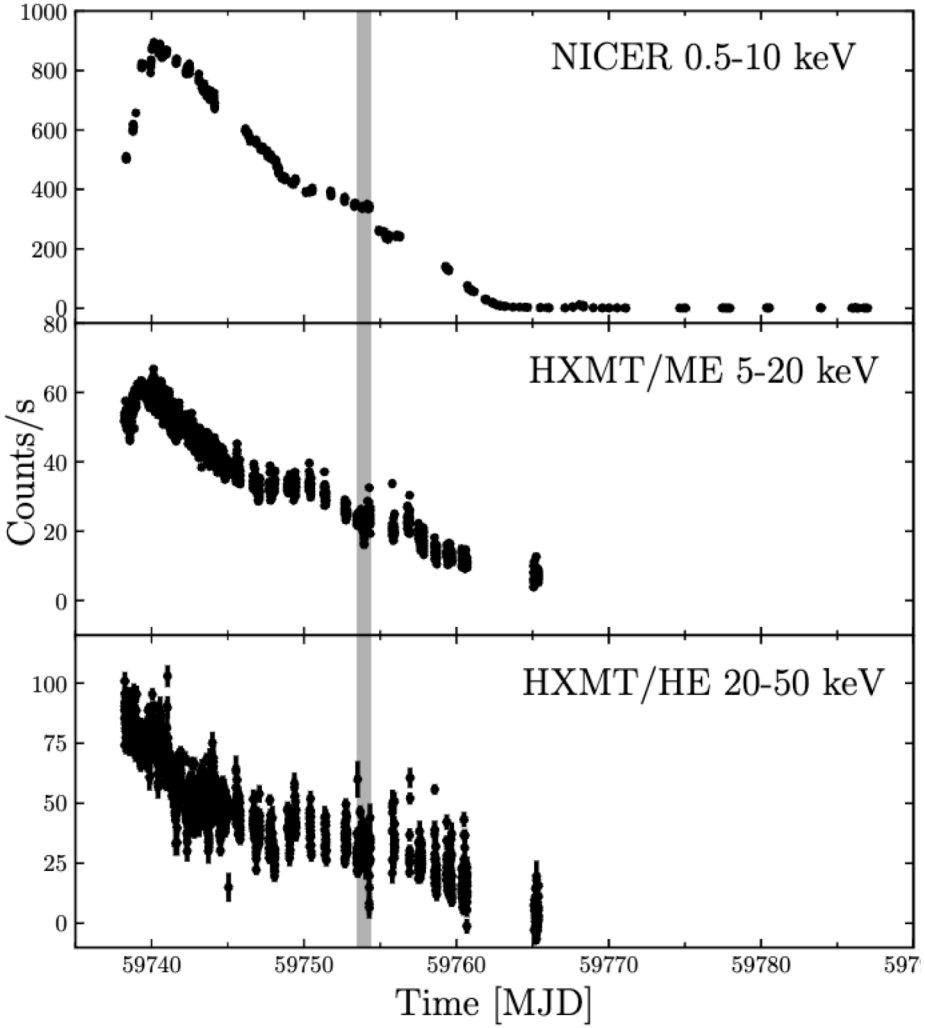


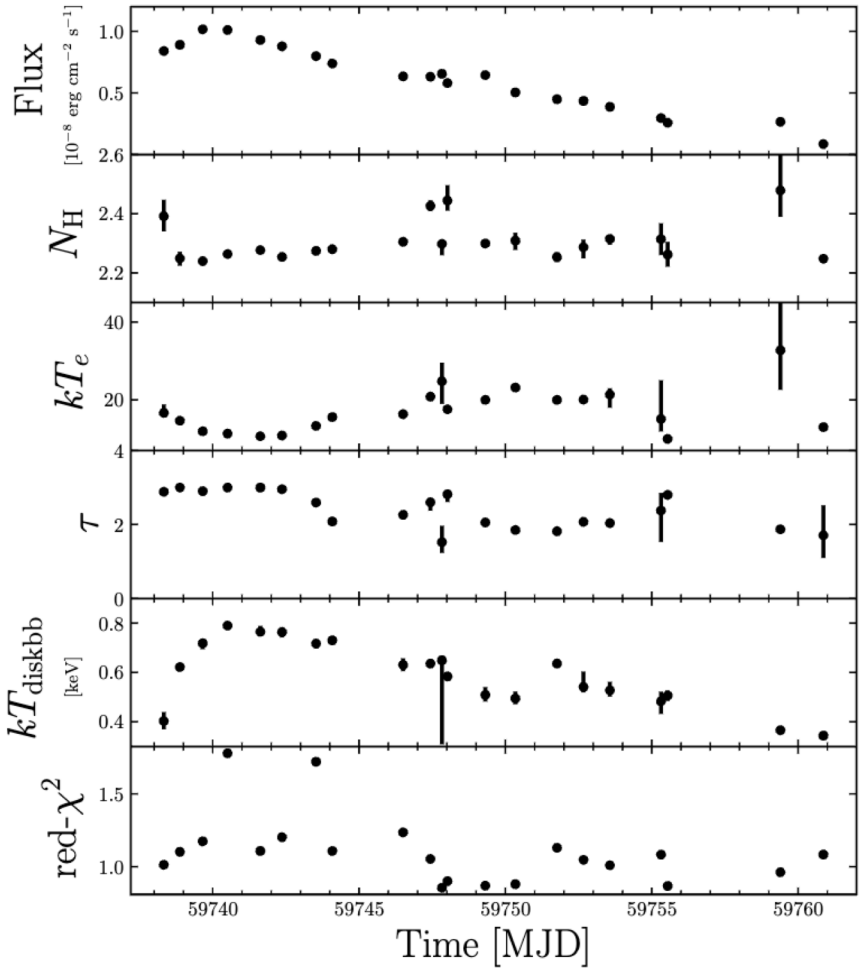
Swift J1756.9-2508

During the 2018 (also for the 2019) outburst, no pulsed emission was detected below 1 keV using NICER and *XMM-Newton* data. *NuSTAR* detected pulsed emission up to ~60 keV during the 2018 outburst. Folding INTEGRAL-ISGRI barycentered data of the 2018 outburst for the 20–60 keV band did not result in a detection of the pulsed emission in line with the expectations given the moderate total outburst flux, low exposure, and low pulsed fraction of $\lesssim$8% (see Sect. 5.2). However, with the *Insight*-HXMT HE instrument, significant pulsed emission has been detected up to ~100 keV (see lower right panel of Fig. 5) in spite of relatively low exposure. This suggests great prospects for future observations with *Insight*-HXMT of the AMXP outbursts.

Li et al. 2021, A&A

MAXI J1816-195 outburst





MAXI J1816-195 timing

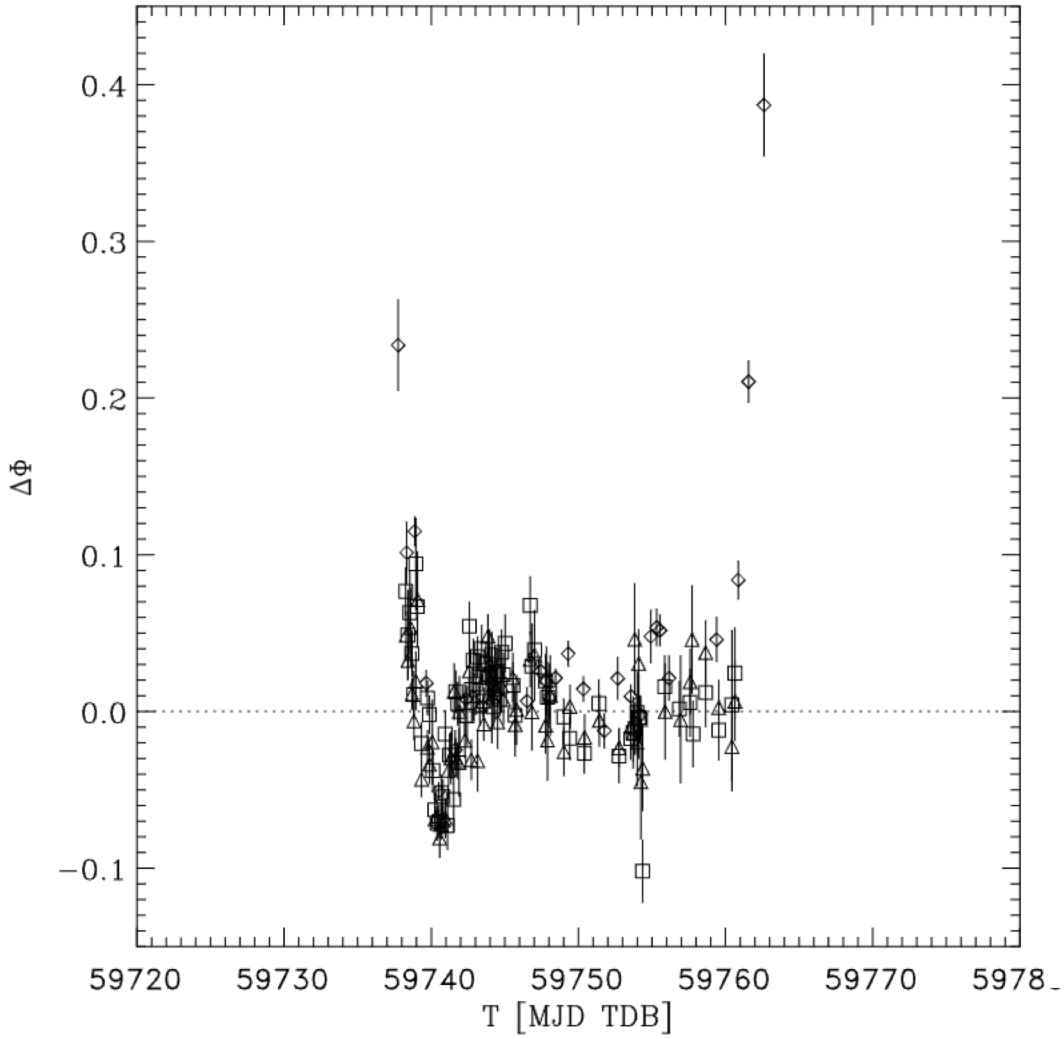
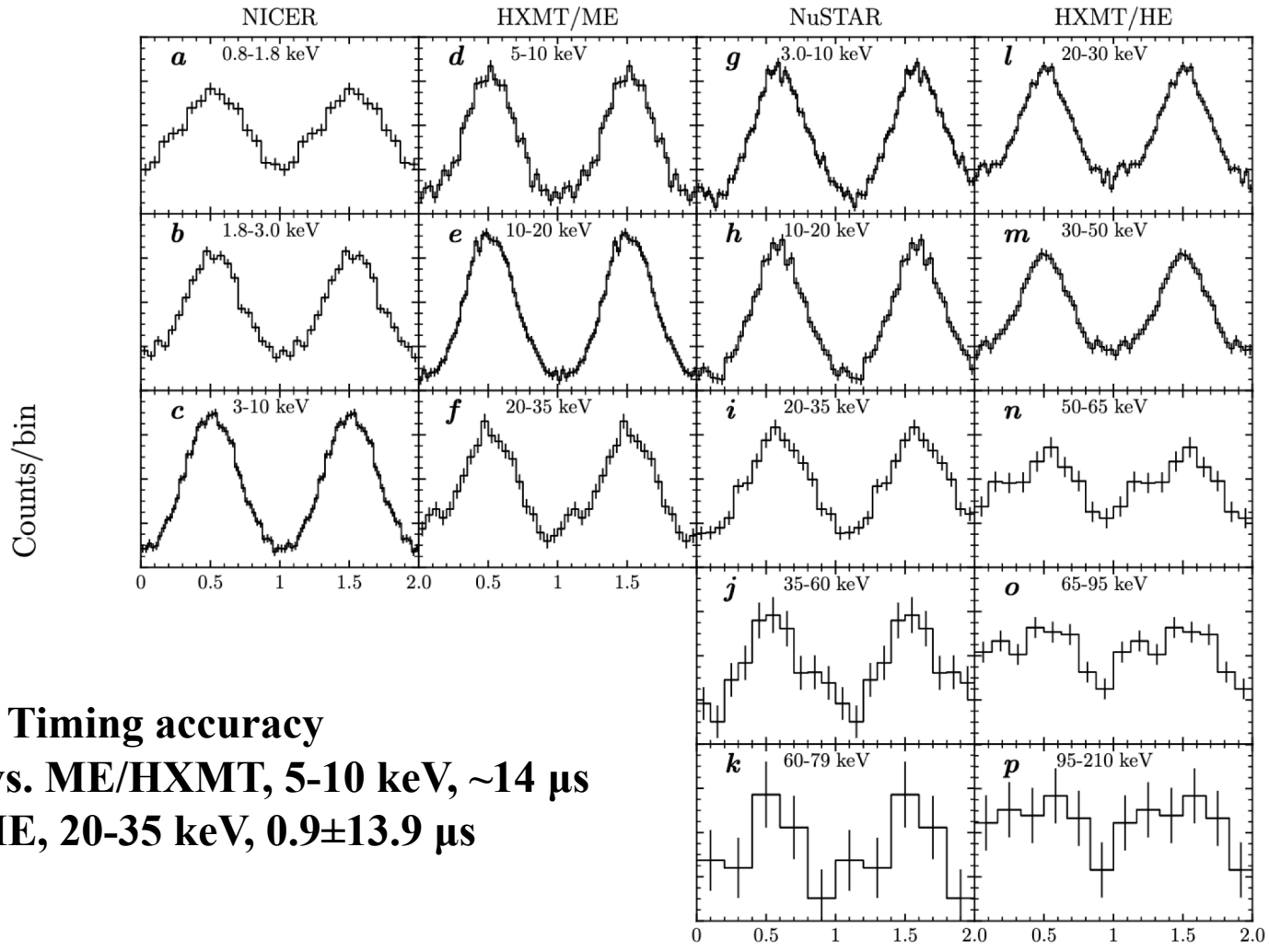


Table 1. Positional, orbital and spin parameters derived in this work and used as fixed values from literature for MAXI J1816−195.

Parameter	Values	Units
α_{2000}	$18^{\rm h}16^{\rm m}52\overset{\rm s}{.}41168(12)$	
δ_{2000}	$-19°37'57\overset{''}{.}40138(473)$	
JPL Ephemeris	DE405	
$P_{\rm orb}$	17402.5786(60)	s
$a_{\rm x}\sin i$	0.262 948(18)	lt-s
e	0 (fixed)	
$T_{\rm asc}$	59738.875 632(4)	MJD (TDB)
Constant Frequency model		
Validity range	59741.9 − 59760.6	MJD (TDB)
t_0 (Epoch)	59741.0	MJD (TDB)
ν	528.611 105 832(4)	Hz
χ^2/d.o.f	$86.78/(47-1) = 1.886$	
Spin-up model		
Validity range	59741.9 − 59760.6	MJD (TDB)
t_0 (Epoch)	59741.0	MJD (TDB)
ν	528.611 105 774(12)	Hz
$\dot{\nu}$	$(9.0 \pm 2.1) \times 10^{-14}$	Hz s^{-1}
χ^2/d.o.f	$68.18/(47-2) = 1.515$	

Spin up ~ 4.3σ c.l.

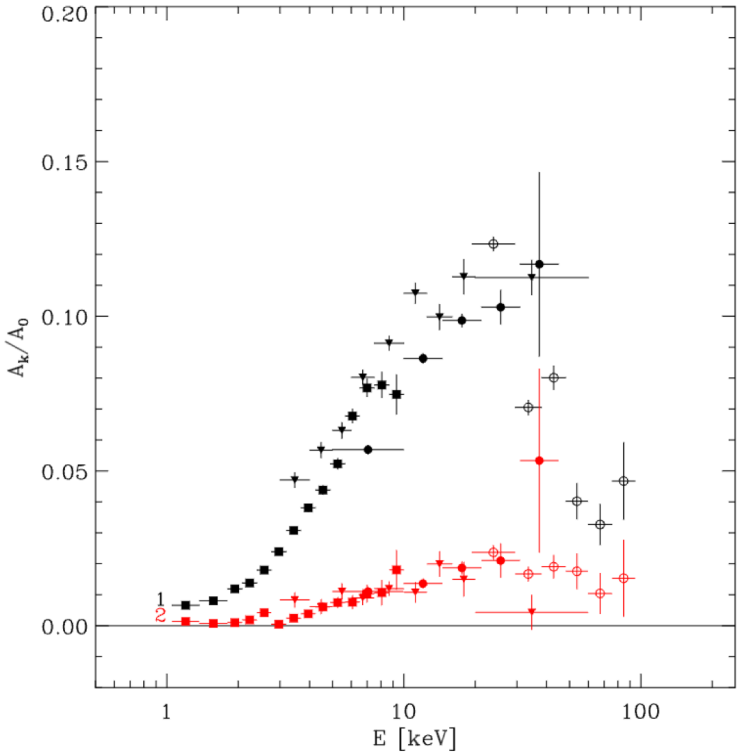
MAXI J1816-195 pulse profile

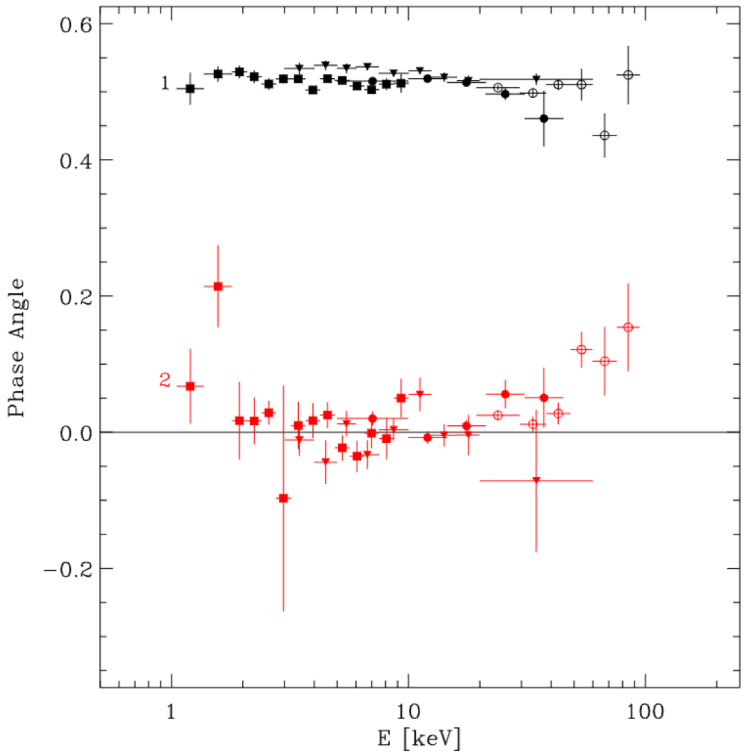


4.4σ

Absolute Timing accuracy
NICER vs. ME/HXMT, 5-10 keV, ~14 μs
ME vs. HE, 20-35 keV, 0.9±13.9 μs

MAXI J1816-195 pulse profile





Li et al. 2023, ApJ submitted

Summary/Future

- **Swift J1756.9-2508**
  - **~20 ks (10 ks GTI) HXMT data produce ~ 5σ pulsation**

- **MAXI J1816-195**
  - **~ 790 ks (180 ks GTI) HXMT data detected spin-up**

- **Future works**
  - **SAX J1808.4-3658, 2.8-3.5σ pulsation**
  - **IGR J17498-2921, ME (5-20 keV; 11.6 σ) and HE (20-60 keV; 18 σ; 60-90 keV ~ 3 σ)**
  - **Constraints on the NS mass and radius**