Supergiant Fast X-ray Transient from the Slowest X-ray Pulsar AX J1910.7+0917 with XRISM/Xtend

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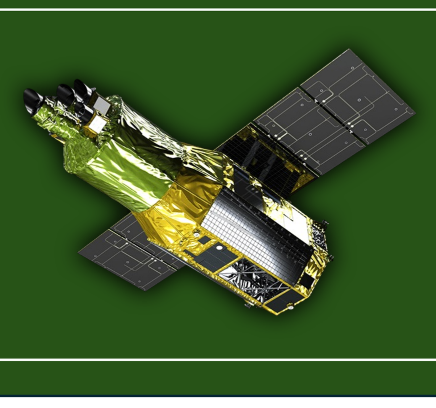


➢ Abstract

XRISM/Xtend has the potential to detect serendipitous X-ray transients thanks to its larger field of view (FOV; 38′×38′) among pointing satellites. AX J1910.7+0917 is known to be the slowest X-ray pulsar, with a rotation period of ~ 10 hours. During observations of the SNR W49B(*, XRISM/Xtend detected a supergiant fast X-ray transient from the HMXB AX J1910.7+0917. We conducted spectral and timing analyses using outburst data over 9 days for AX J1910.7+0917. The time-averaged spectrum was reproduced with an absorbed power-law model and the luminosity was obtained as $1.8^{+0.1}_{-0.1} \times 10^{35}$ erg s^{-1} (1−10 keV). We also confirmed the Fe emission lines in bright phase spectra. Assuming the line width is due to the Doppler broadening, the Keplerian radius is consistent with Alfvén radius with a magnetic field of 10^{12} G. In timing analysis, we detect the pulsation with a period of 3.6−3.9×10^4 s. Additionally, the period may be correlated with the flux. These results are important to understand the settling accretion onto magnetized NSs.

(*Target team leads: M.Sawada & G.Brown

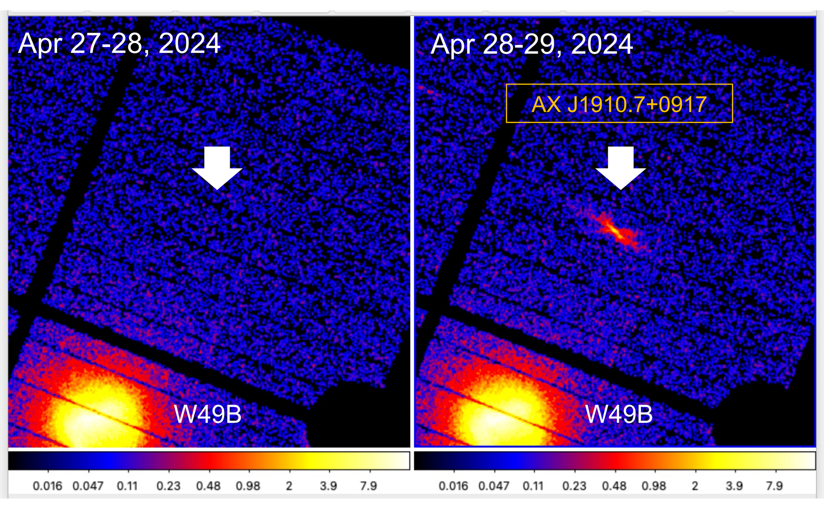
➢ Introduction

Neutron stars (NSs) exhibit a great variety of rotation periods P and magnetic field strengths B. While rotation-powered pulsars show clear correlations between P and B, accretion-powered pulsars present more complexity due to angular momentum transfer by accretion flow. As accretion mechanisms on NSs, for instance, the wind-type, Be-type, and Roche-lobe types have been proposed.

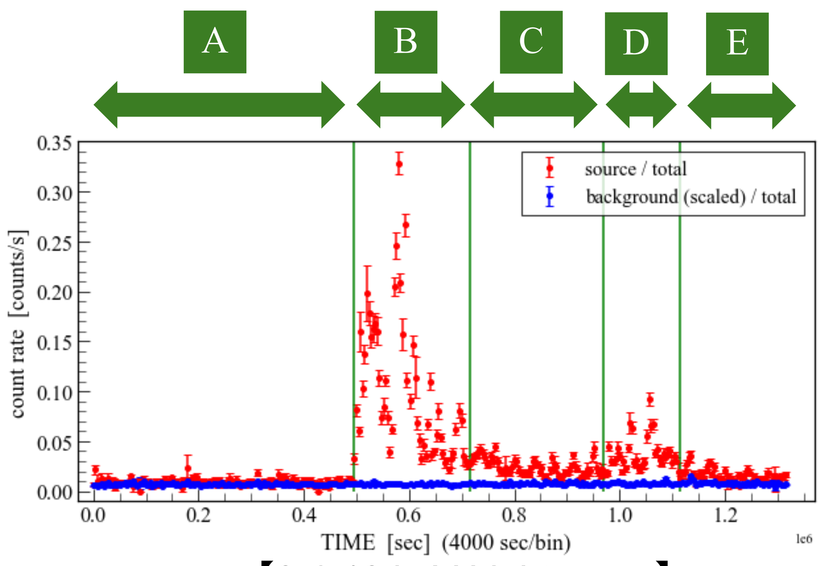
AX J1910.7+0917 is known as "the slowest X-ray pulsar". The rotation period was determined to be 36200 s (~ 10 hours) based on Chandra observations (Sidoli et al. 2017). Its companion is a B-type star, identifying the system as a high-mass X-ray binary (Rodes-Roca et al. 2013). Investigating how AX J1910.7+0917 lost angular momentum could provide insight into the evolution of NS accretion mechanisms.

➢ SFXT from AX J1910.7+0917

Supergiant Fast X-ray Transient (SFXT) from AX J1910.7+0917 was detected in the XRISM observation for the SNR W49B (~12′ apart) in April 2024. The observations of W49B were scheduled for two weeks, allowing us to collected data on the outburst of AX J1910.7+0917 over 9 days.
(The first observation that captured the entire outburst!)



【0.4-10 keV Image】



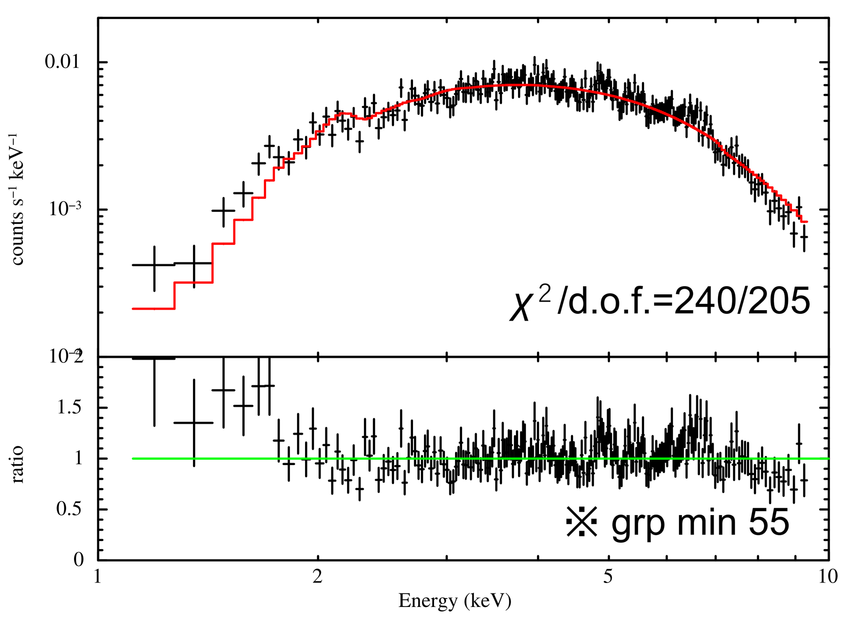
【0.4-10 keV Light curve】

➢ Time-averaged spectrum

The time-averaged spectrum in the outburst was reproduced with an absorbed power-law model. The best-fit parameter was as follows:

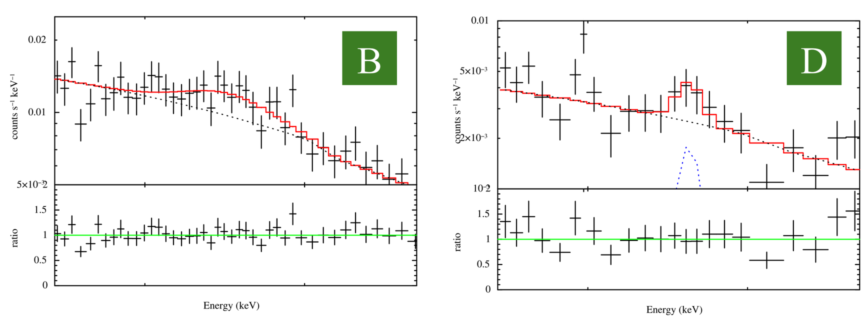
- N_H: $5.9^{+0.3}_{-0.4} \times 10^{22}$ cm^2
  (> 1.5×10^{22} cm^2; galactic absorption)
- Γ: $1.66^{+0.09}_{-0.08}$
- flux: $5.9^{+0.3}_{-0.3} \times 10^{-12}$ erg s^{-1} cm^{-2}
- luminosity: $1.8^{+0.1}_{-0.1} \times 10^{35}$ erg s^{-1} (1−10 keV)

⇨ Typical HMXB outburst



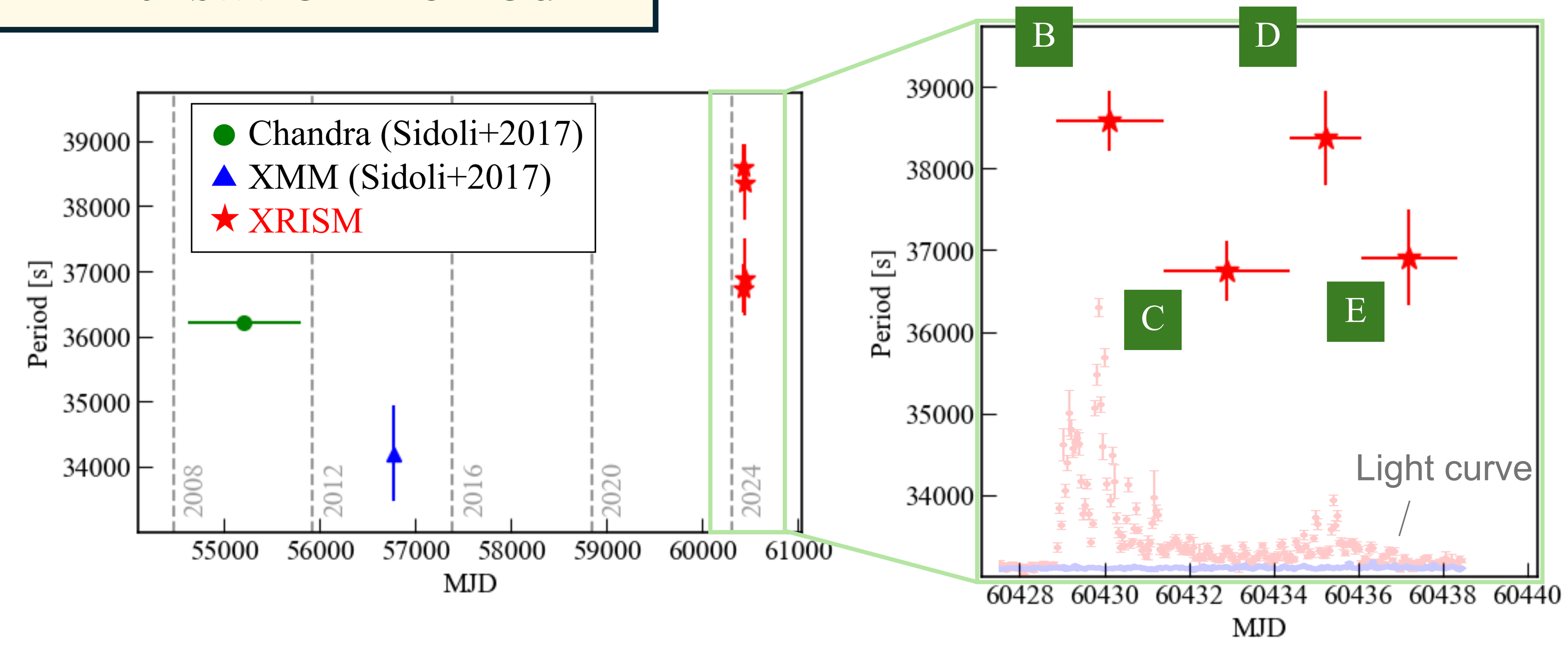
➢ Fe emission line

In the bright (B, D) phase, Fe emission lines are detected at 6.4 − 6.7 keV (90% error). Assuming the origin of the Fe emission lines is the accretion disk illuminated by the accretion column, the Keplerian radius is derived to be $1.3^{+7.4}_{-0.9} \times 10^3$ km from the results of phase B. It is consistent with the Alfvén radius with B = 10^{12} G.



Phase	Energy [keV]	Sigma [keV]	Eq width [keV]
A	fixed to B	fixed to B	−
B	$6.5^{+0.2}_{-0.1}$	$0.26^{+0.20}_{-0.16}$	$0.16^{+0.09}_{-0.10}$
C	fixed to B	fixed to B	< 0.38
D	$6.6^{+0.1}_{-0.1}$	< 4.2	< 0.14
E	fixed to B	fixed to B	−

➢ Pulsation Period

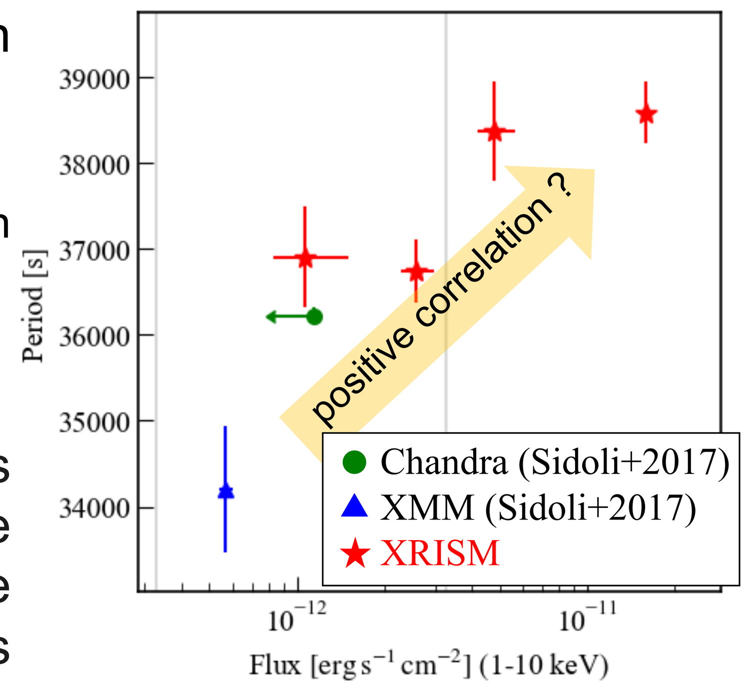


We searched for pulsations using the Z^2 method and detected the periodicity of 3.6−3.9×10^4 s except for phase A. The period differed by about 10% between the bright (B, D) and non-bright (C, E) phases. The long-term trend of the period was found to be slowed down by 1-13% in P about 10-15 years, compared to previous studies. For example, the period derivative between Chandra and XRISM (14 years) is 10^{-6} s s^{-1}, which is comparable to supercritical accretion NSs. (It is noted that the luminosity of AX J1910.7+0917 was ~ 10^{-3} $L_{\rm Edd}$!)

Moreover, there may be a positive correlation between brightness and rotation period, unlike typical accretion pulsars.

<Possible Causes>

1. The direction of NS rotation and the direction of the accretion disk rotation are opposite.
2. Quasi-spherical settling accretion
   (e.g., Shakura et al. 2012,2017, Sidoli et al. 2017)



However, if the rotation period is slow as that of AX J1910.7+0917, we may observe luminosity variations due to changes in the accretion rate rather than rotation. This possibility must be discussed carefully.

➢ Time variability for the spectral parameter

We divided the light curve into five phases (A, B, C, D, and E) and examined the time variability of the spectral parameters. The XRISM observations cover two orders of magnitude in flux, which are consistent with those seen in previous studies. There was no apparent correlation between the photon index and absorption. On the other hand, flux and the photon index seemed to be inversely correlated. It can be interpreted as looking at the deeper, hotter part of near the NS surface in bright phases.