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MAGNESIA

The first outburst of the young magnetar Swift J1818.0-1607

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Transient Universe 2023

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Manual de uso del logotipo MAGNESIA

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Deep X-Ray and Radio Observations of the First Outburst of the Young Magnetar Swift J1818.0−1607

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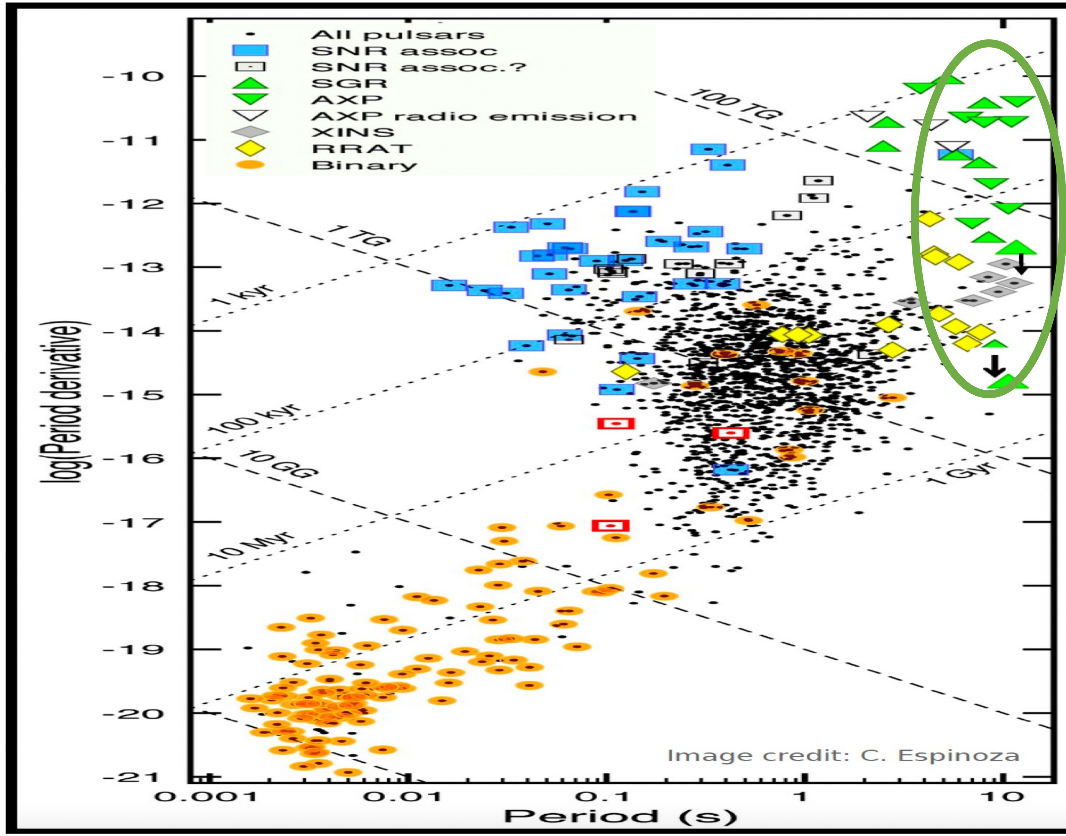
Transient Universe 2023

Introduction

Magnetars

- A sub-group of isolated neutron stars with ultra-high magnetic fields of 10^{14} --10^{15} G.
- The decay of their B powers their electromagnetic radiation
- P ~ 0.3 – 12 s
- Pdot ~ $10^{-13} - 10^{-11}$ s s^{-1}
- Soft X-ray emission with luminosities in the range of $L_X \sim 10^{31} - 10^{36}$ erg s^{-1}



Duncan & Thompson (1992); (Kaspi & Beloborodov 2017; Esposito et al. 2021)

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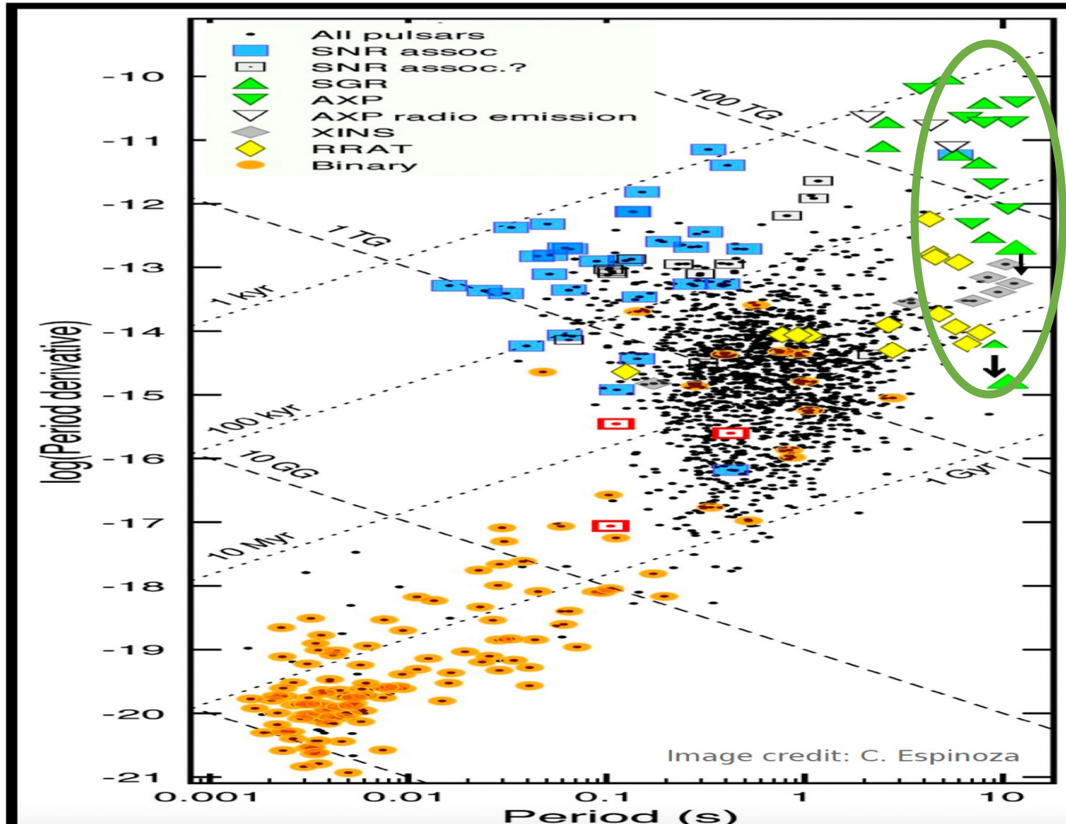
Transient activities:
Outburst: Large (factor of 10--1,000) and sudden increase in the source X-ray flux (10^{36} erg s^{-1})



Duncan & Thompson (1992); (Kaspi & Beloborodov 2017; Esposito et al. 2021)

The discovery of Swift J1818

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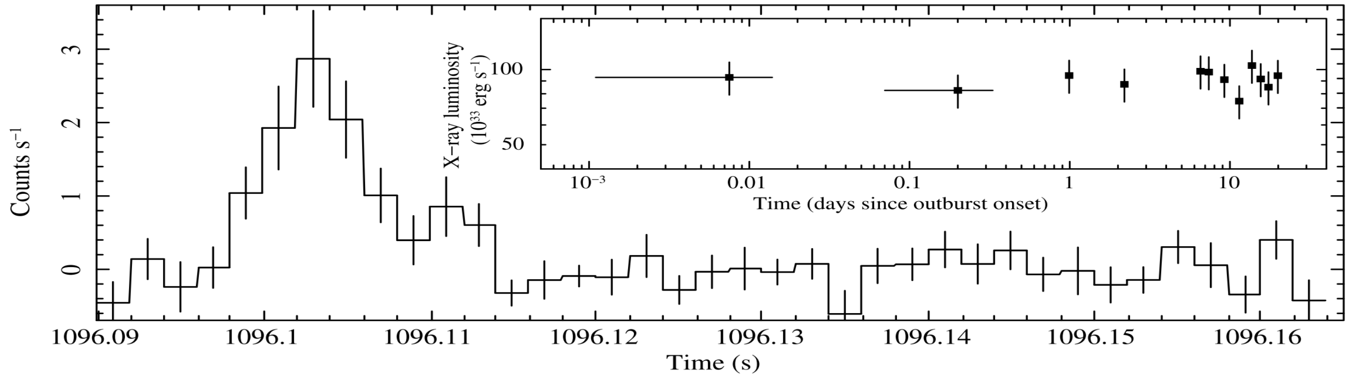
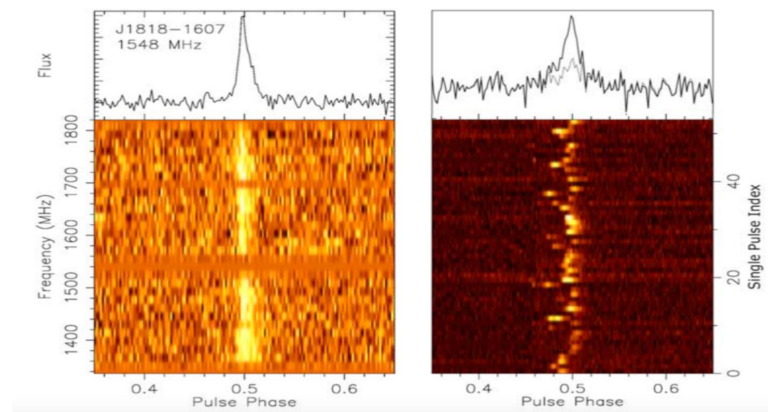
- Discovered in 2020 March through an outburst.
- P ~ 1.36 s
- Radio observations confirmed Swift J1818 as the fifth radio-loud magnetar
- Pdot ~ 8.2×10^{-11} ss^{-1}
- B ~ 3.4×10^{14} G (leads to tau ~ 265 yr)





Ref: Esposito et al. 2020; Evans et al. 2020; Karuppusamy et al. 2020; Champion et al. 2020)

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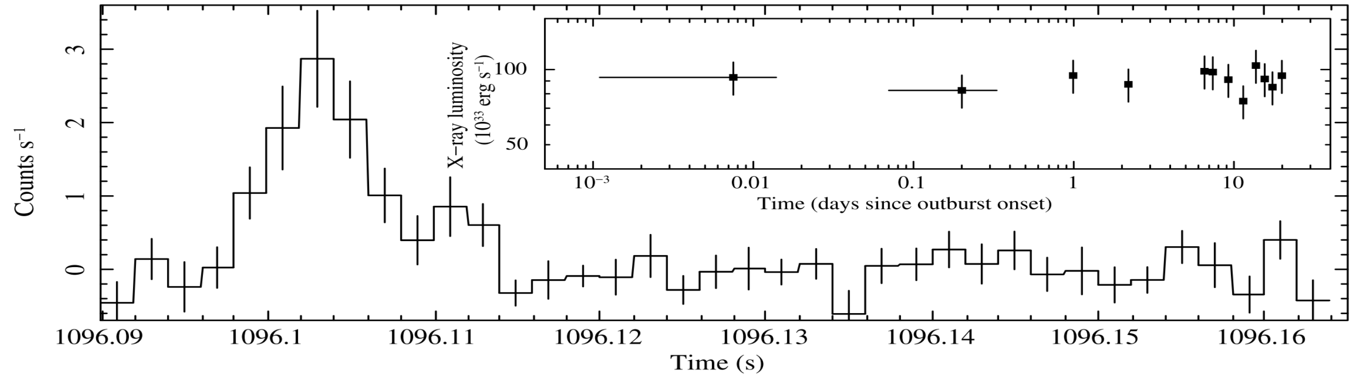

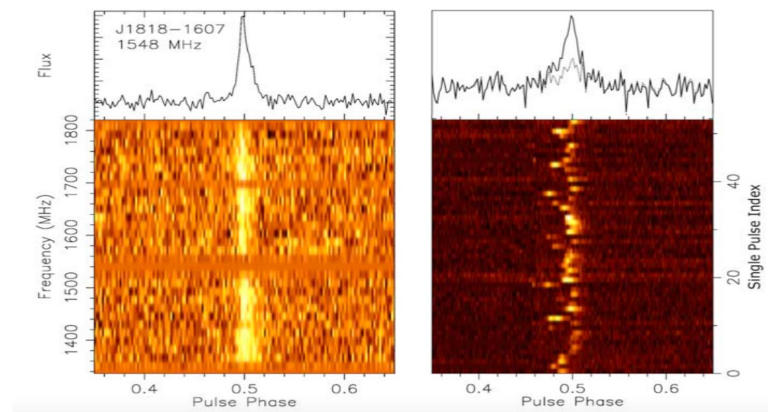

Here, X-ray monitoring campaign with X-ray instruments shortly after its outburst from March 2020--October 2021 (19 Months)

Ref: Esposito et al. 2020; Evans et al. 2020; Karuppusamy et al. 2020; Champion et al. 2020)

Spectral Analysis

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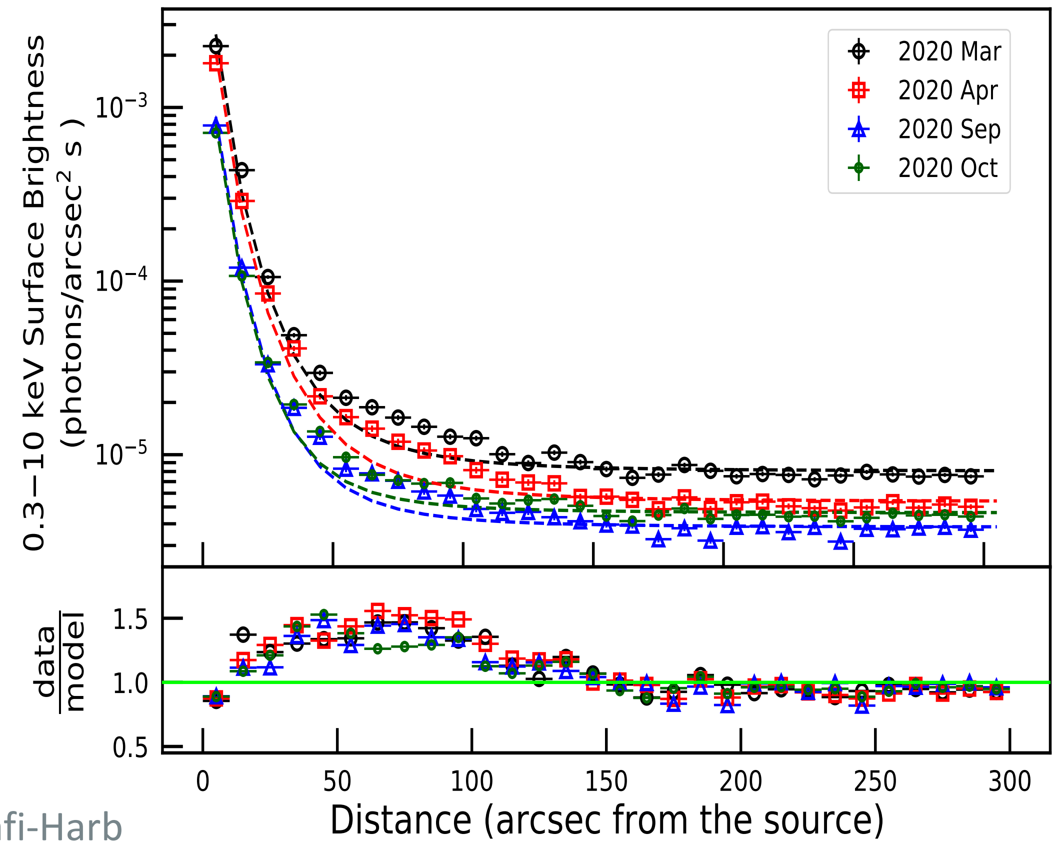
Diffuse X-ray emission

- The spatial extent of the diffuse emission in EPIC-pn:
- extract a radial profile of the observed surface brightness (up to 300") and fit with the king function (PSF)



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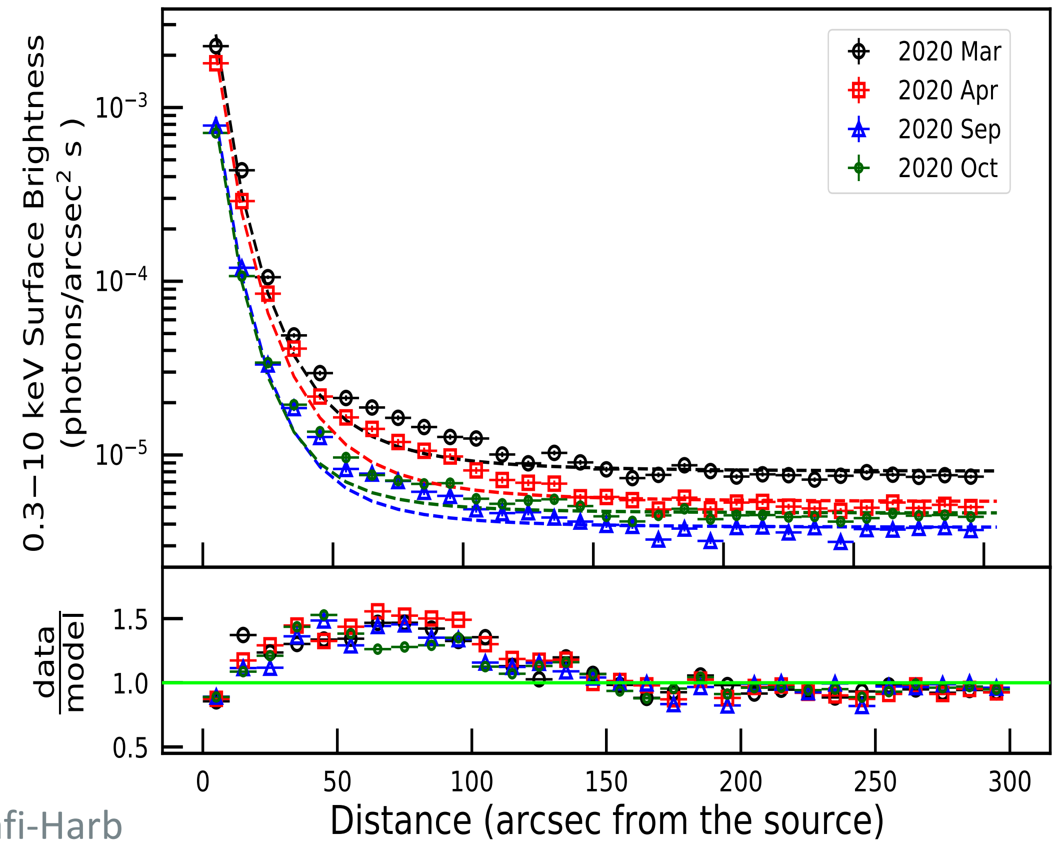
diffuse emission within ~ 50" – 110"



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Spectral Analysis

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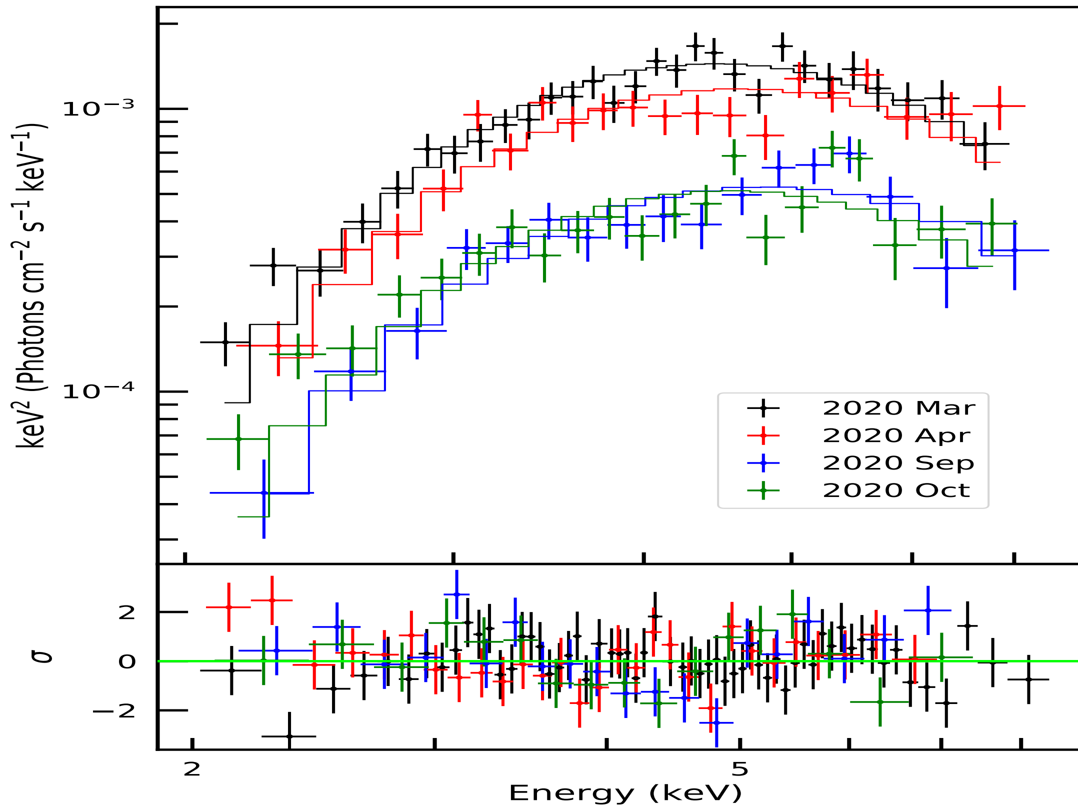
Diffuse X-ray emission

- Then, we extract 0.2--7.5 keV spectra by selecting photons with an annulus (50''--110'') cantered on the source.
- The best fit ($\chi^2 \sim 1.2$) with a single BB model



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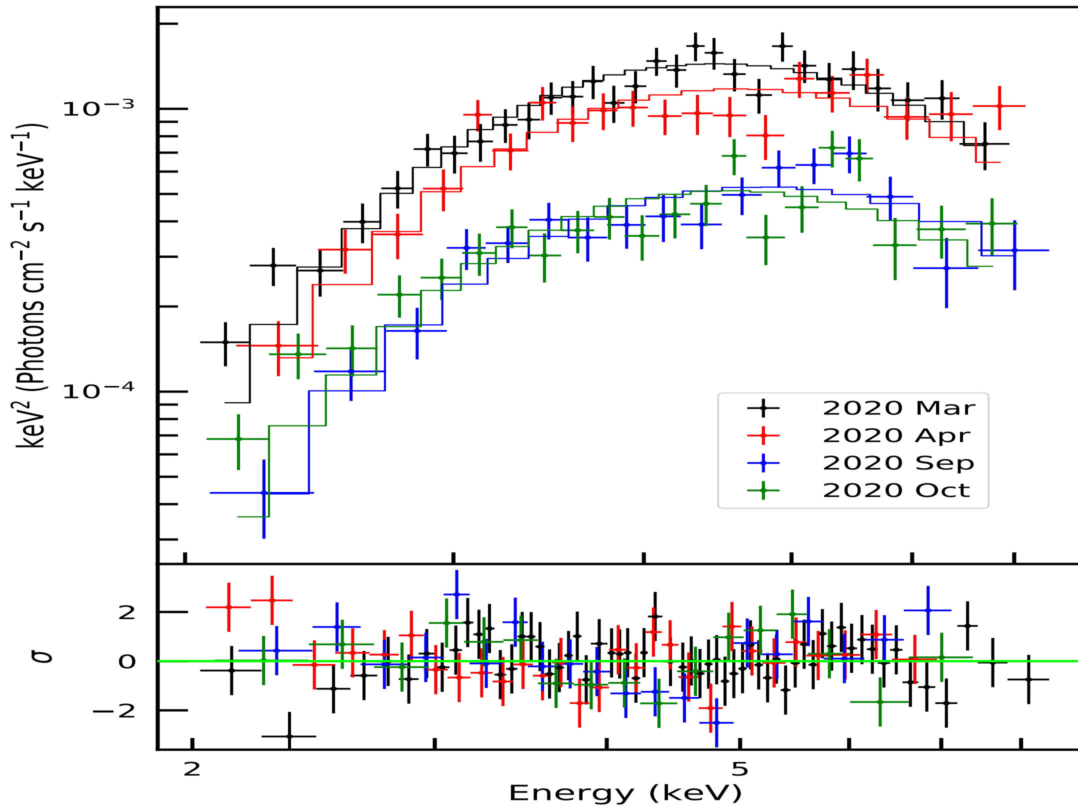
⬇

35% flux reduction of the diffuse X-ray emission ➔ the dust scattering-halo is the main source of the diffuse X-ray emission



Spectral Analysis

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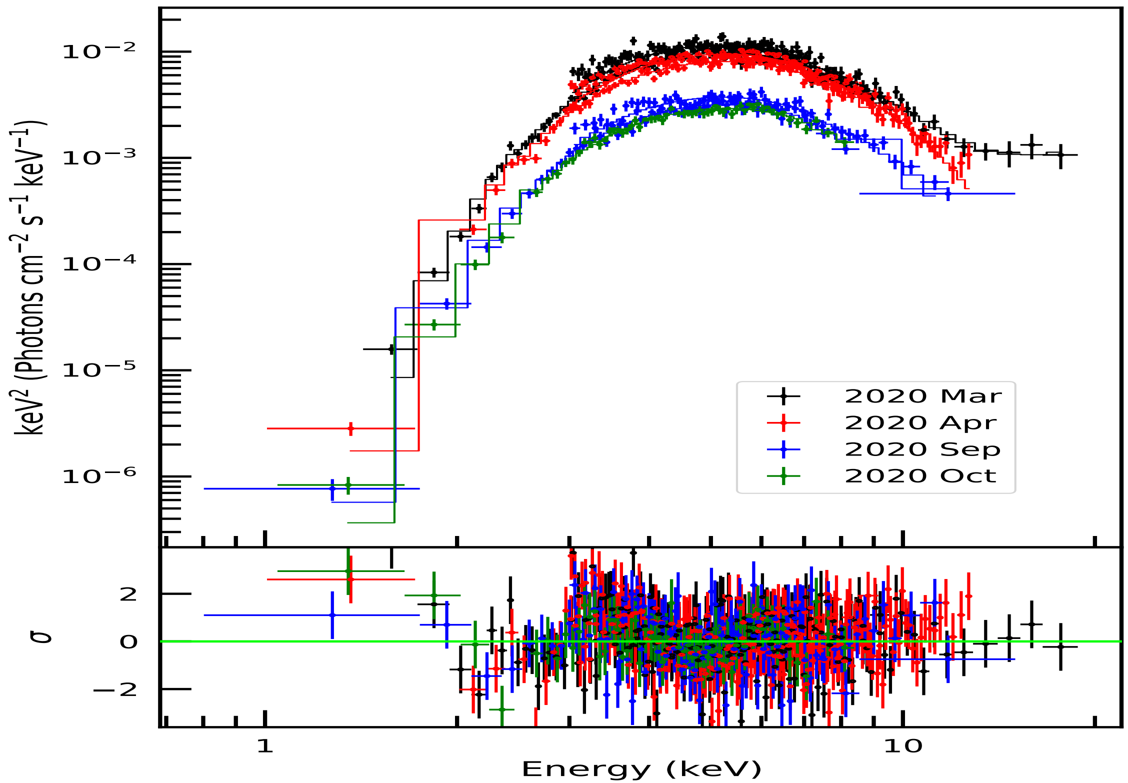
X-ray emission of Swift J1818

- Performed following the standard procedure with XSPEC
- Spectra from EPIC-pn (1--10 keV) and NuSTAR/FPMA(3--13 keV)
- Best model: BB+PL with a reduced ch^2 = 1.4



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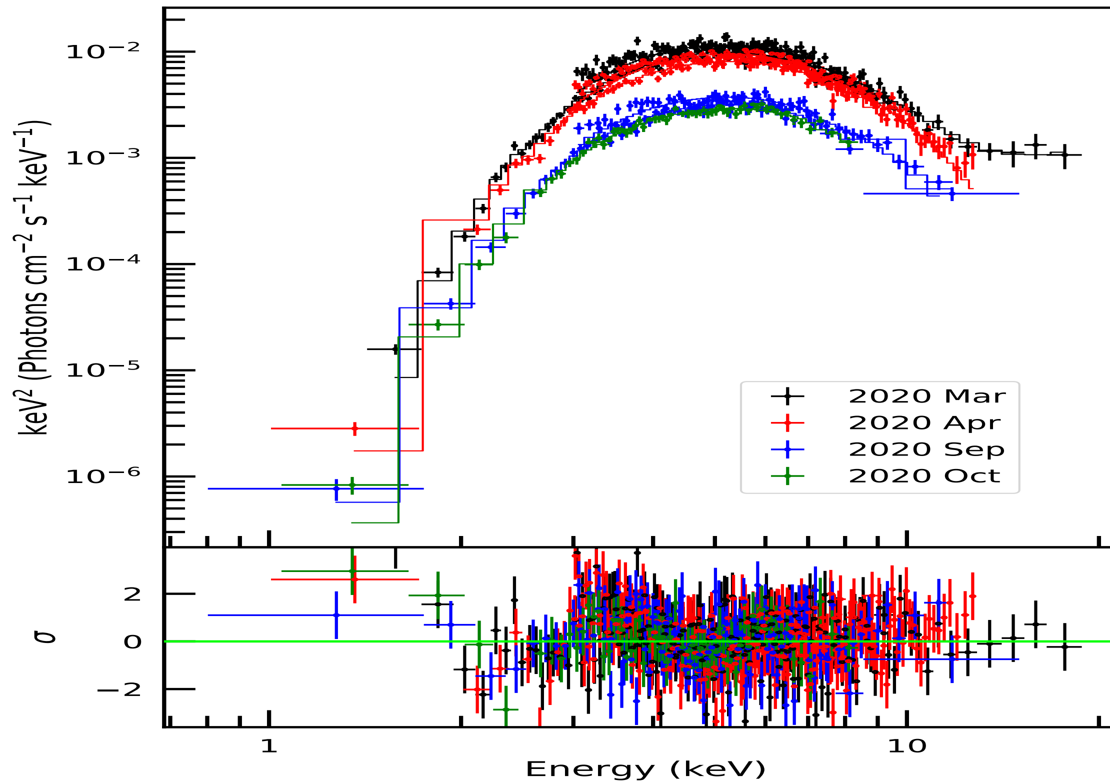
$N_H \sim 1.24\ (0.02) \times 10^{23}\ cm^{-2}$

$kT_{BB} \sim 1.1$ keV

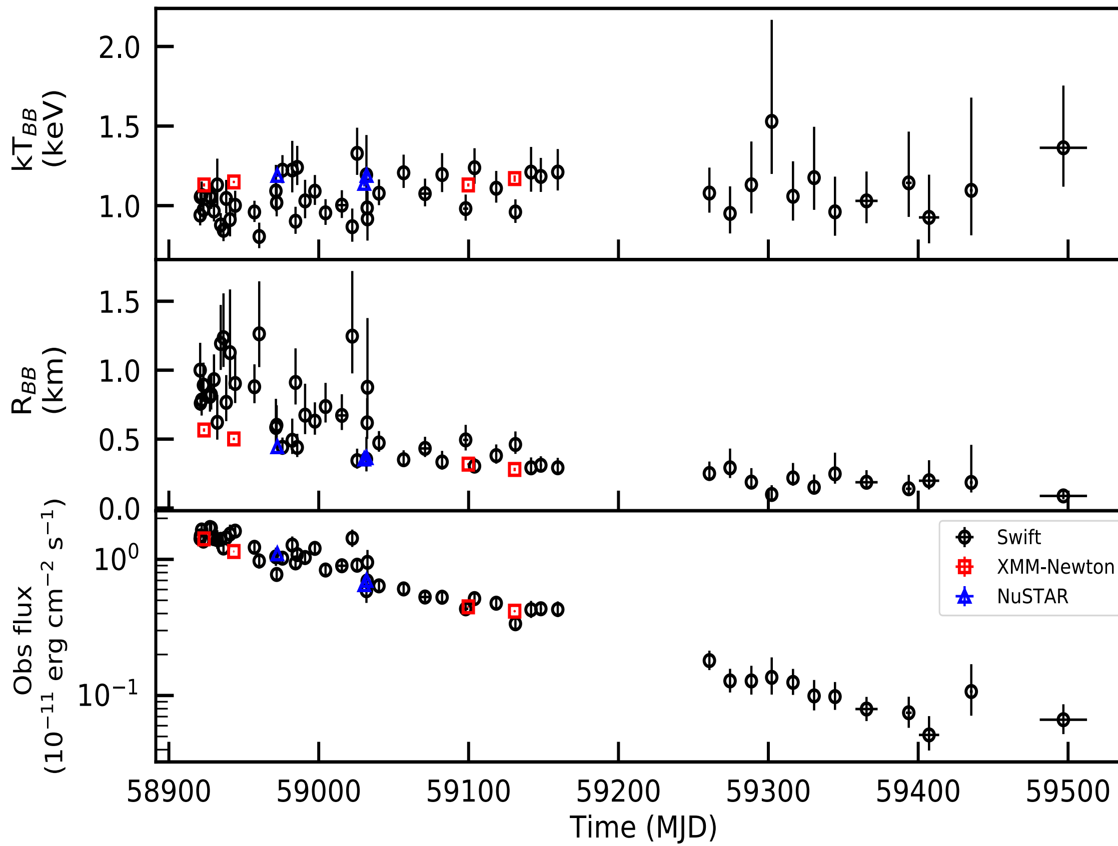
$\Gamma \sim 1.0\ (+/-0.6)$



Spectral Analysis

Long-term spectral evolution

- Swift/XRT monitoring campaign
- Modelled with an absorbed BB model (fixed N_H)



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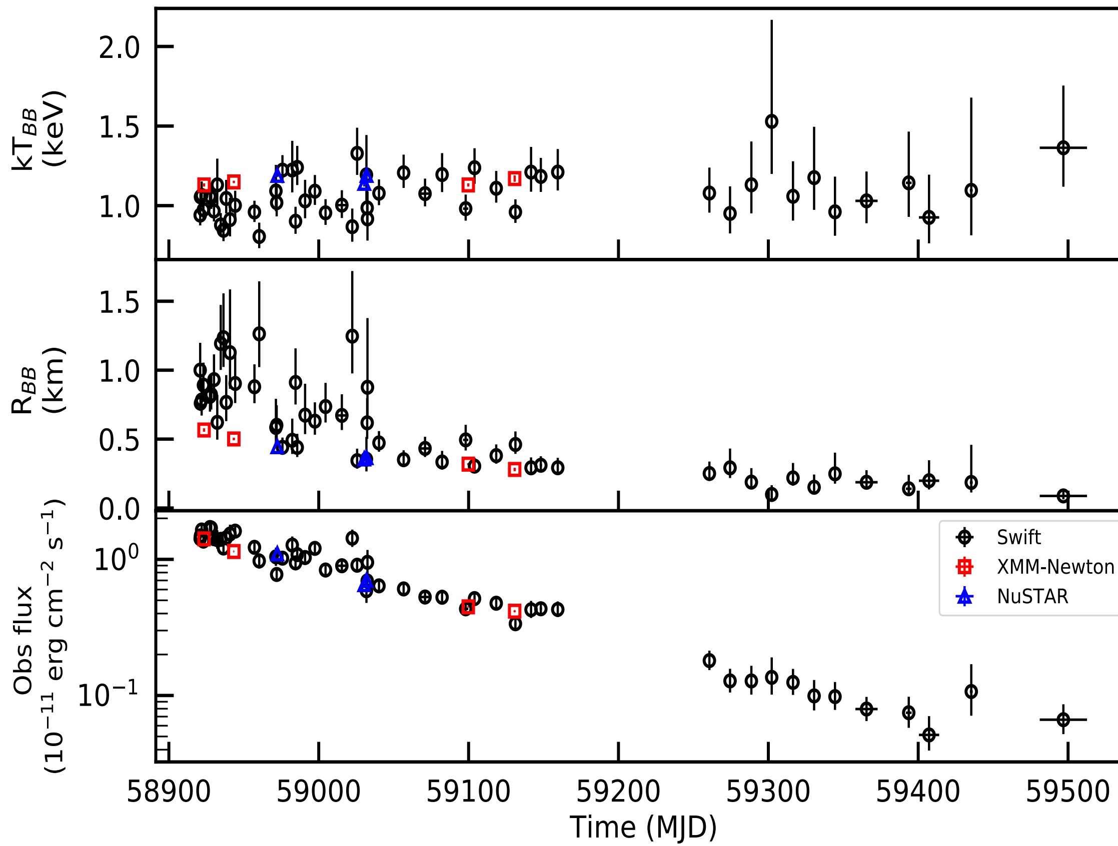
- Rabid decay of the 1--10 keV flux (1.4×10^{-11} -- 6.6×10^{-13} erg s^{-1} cm^{-2})



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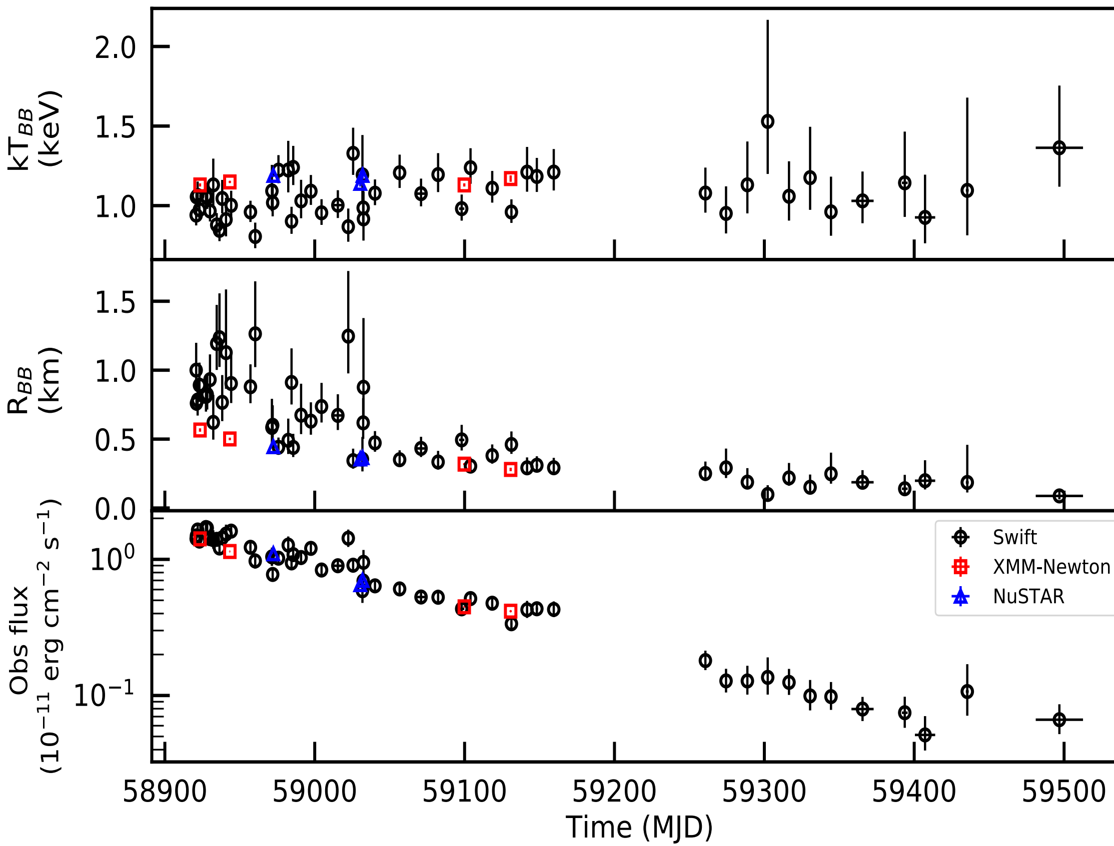
- Decreasing on the BB radius during the first seven months, from 0.6 to 0.3 km then settled at an average of 0.2 km



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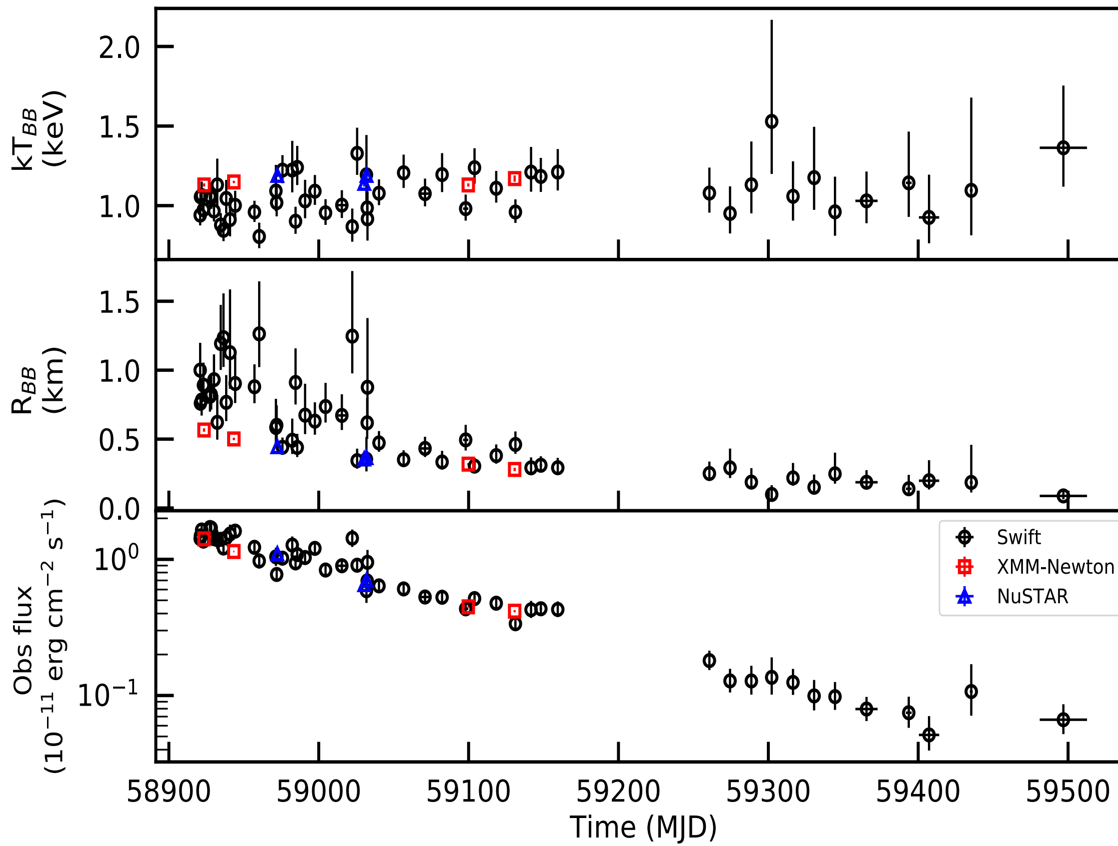
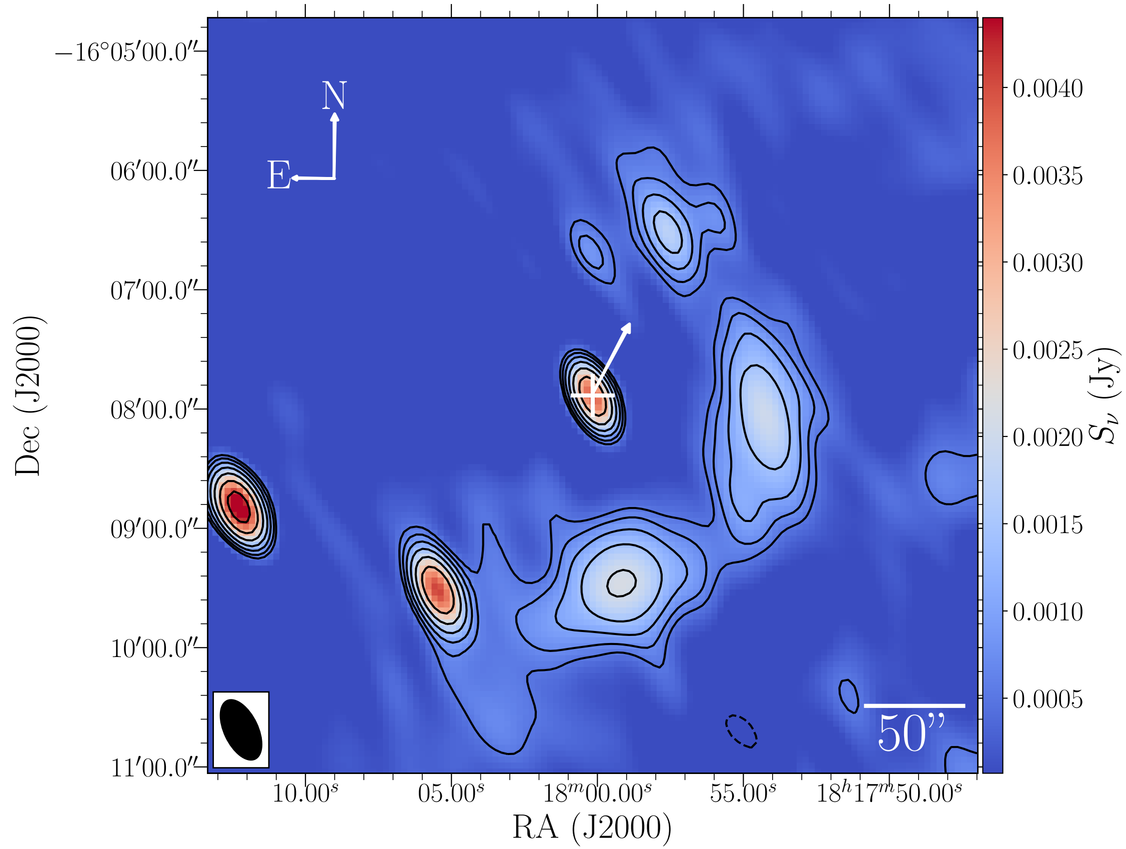
- Decreasing on the BB radius during the first seven months, from 0.6 to 0.3 km then settled at an average of 0.2 km
- Almost a constant blackbody temperature of 1.1 keV



Radio observations

- Performed with VLA in 2021 March 22, within S-band
- A radio counterpart of the J1818 (as a point source) with peak flux density of 4.38 (0.05) mJy
- A bright half-ring of the diffuse structure at 90" to the west of the source



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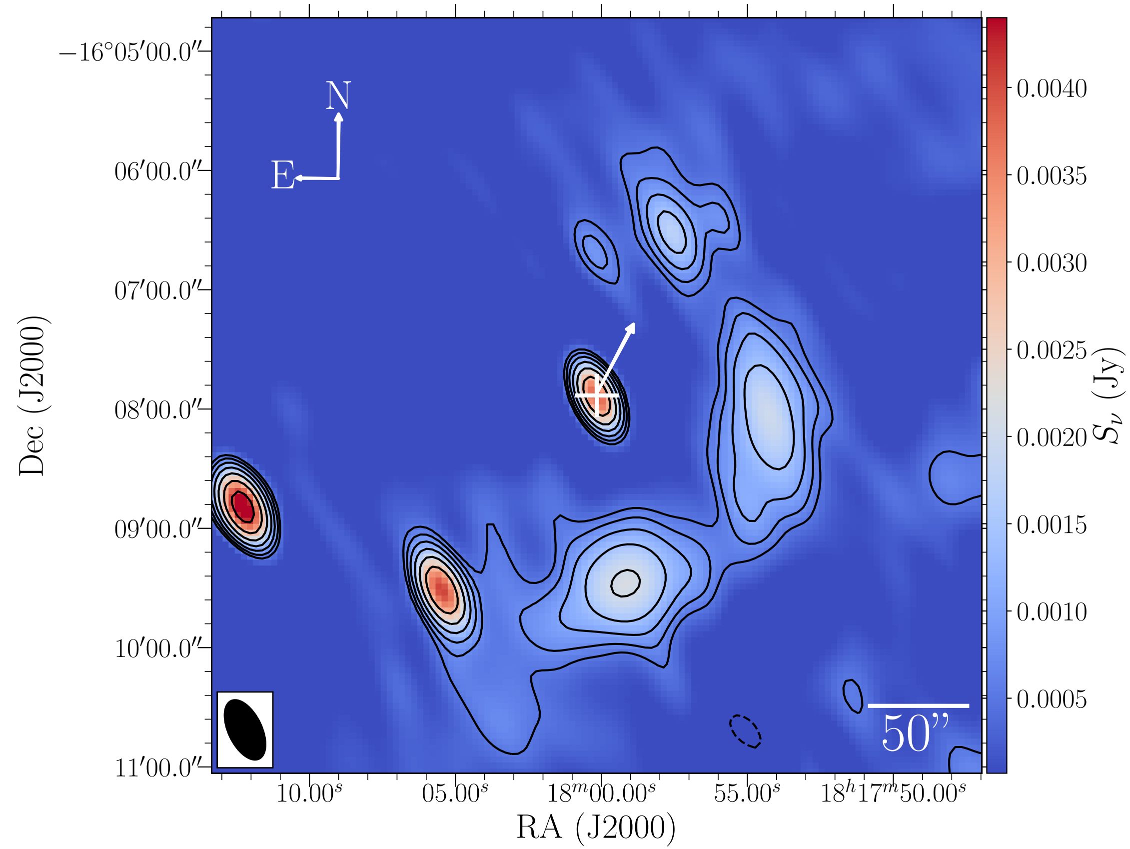
This could be associated with the supernova remnant of this young magnetar



Timing Analysis

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- Phase-coherent timing solution was not feasible due to during the phase connection procedure.
- The spin frequency for each epoch were calculated using ToAs (obtained from PINT photonphase tool) and Tempo.

Instrument/Obs.ID	Ref. Epoch (MJD)	ν (Hz)
XMM/0823591801	58923.40	0.7334073(7)
NuSTAR/80402308002	58923.40	0.7334068(2)
XMM/0823593901	58943.30	0.733356(6)
NuSTAR/80402308004	58944.00	0.7333558(6)
NuSTAR/80402308006	58972.40	0.73329(3)
NuSTAR/80402308008	59030.40	0.7331763(4)
NuSTAR/80402308010	59031.90	0.733173(1)
NuSTAR/80402308012	59099.50	0.7330509(3)
XMM/0823594001	59099.80	0.7330506(5)
XMM/0823594201	59130.60	0.7330035(5)

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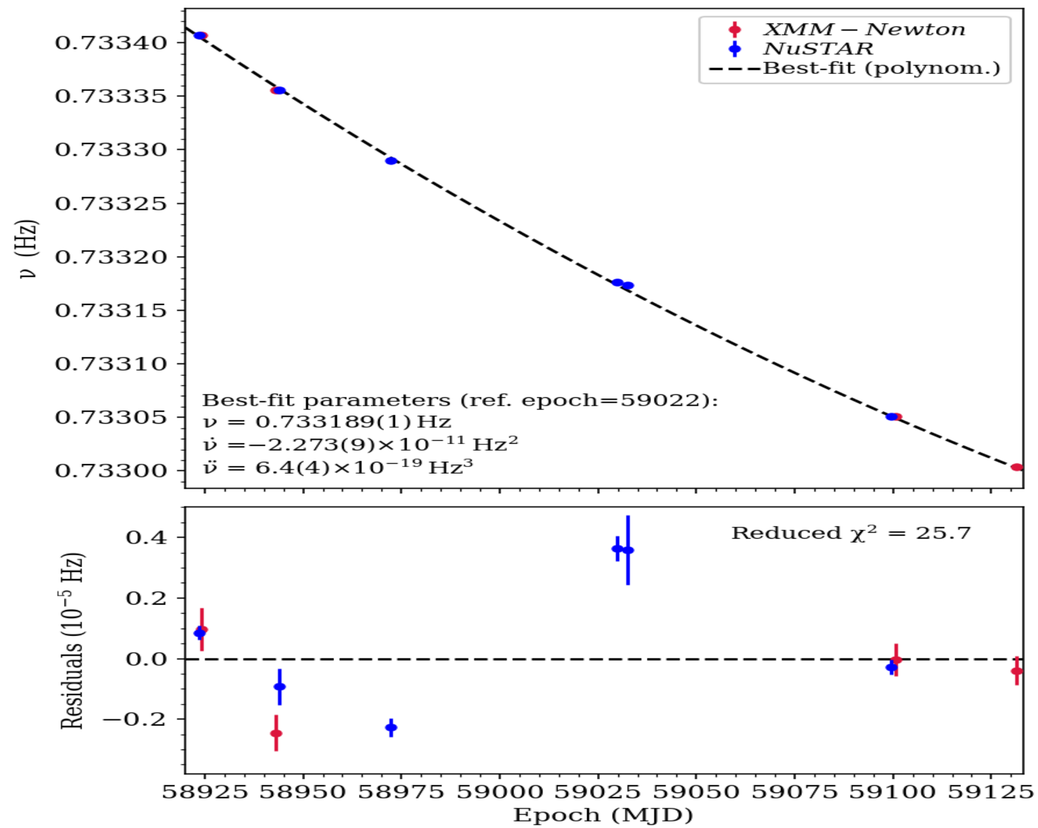
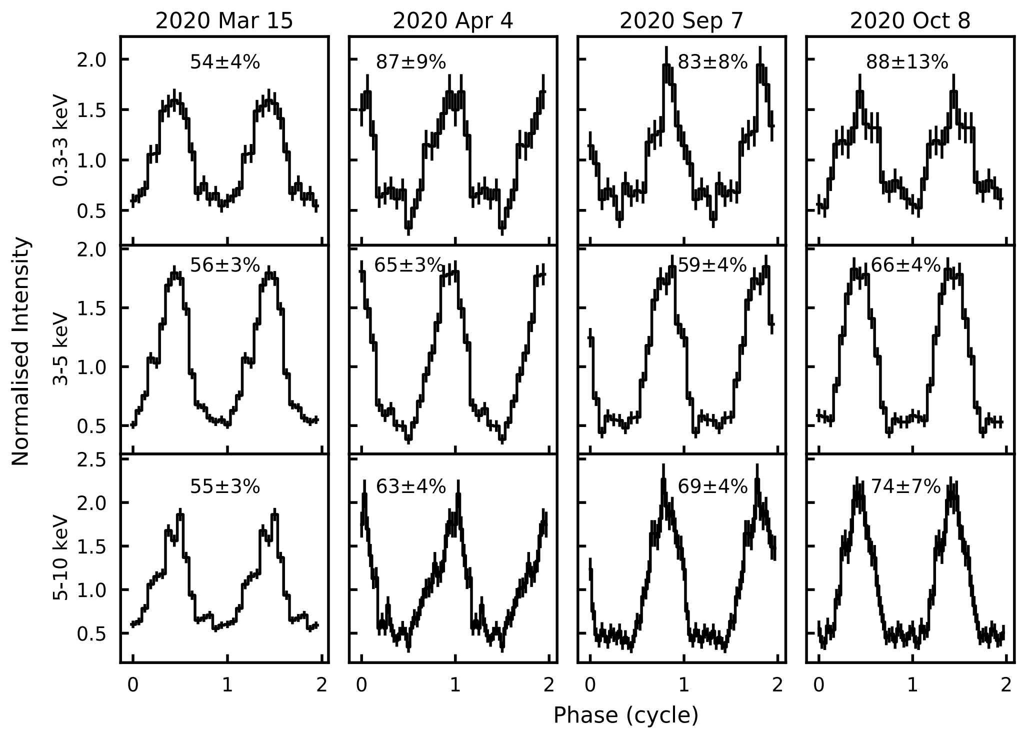
- The spin frequency for each epoch were calculated using ToAs (obtained from PINT photonphase tool) and Tempo.
- The long-term average spin evolution v(t) was fit with a second order polynomial function
- The best-fit spin-down rate of $-2.273(9)\times10^{-11}$ Hz^2 on MJD 59022
- The large ch^2 is due to the large time gaps between the observations



Timing Analysis

X-ray pulse profile

- To investigate possible changes in the shape and amplitude of the X-ray with the photon energy:
- Energy-resolved pulse profiles extracted from the EPIC-pn data sets in three energy bands
- Increasing pulsed fraction (PF) for a given energy band
- For the 0.3--10 keV energy interval: increased with time, from (53±2)% to (64±3)% between March and October 2020



Summary

- Swift J1818.0–1607 is a very young and radio-loud magnetar magnetar with a spin period of 1.36 s
- The long-term spectral evolution shows a rabid decay in the 1--10 keV flux
- The timing analysis revealed large torque variability, with an average spin-down rate of -2.3×10^{-11} Hz^2
- Confirm the bright diffuse X-ray and radio emission
- The diffuse X-ray emission might be due to a dust scattering halo and that the radio structure may be associated with the supernova remnant of this young pulsar, based on its morphology

Muchas Gracias

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