On the nature of the X-ray pulsar XTE J1859+083 and its broadband properties

arXiv:2111.08997, DOI: 10.1093/mnras/stab3362

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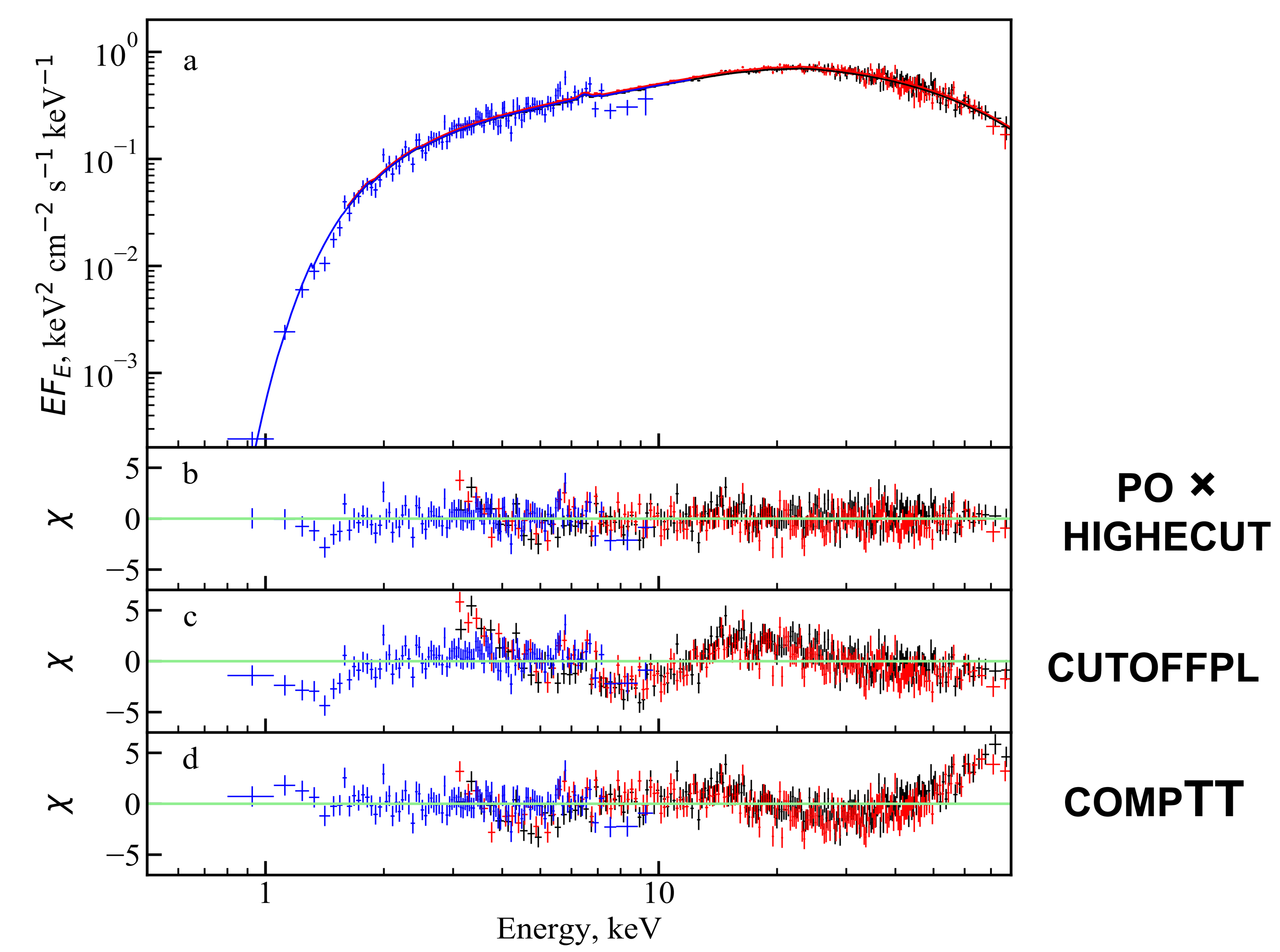
Abstract

This work is devoted to the study of the broadband 0.8–79 keV spectral and timing properties of the poorly studied XRP XTE J1859+083 during its 2015 outburst based on *NuSTAR* and *Swift* data.

The source pulse profile has complex energy-dependent shape. Pulse fraction of XTE J1859+083 has constant value around 35%. Its energy spectrum has a power-law shape with an exponential cutoff at high energies. No cyclotron absorption line was discovered in the source spectrum. An estimation was made for magnetic field strength.

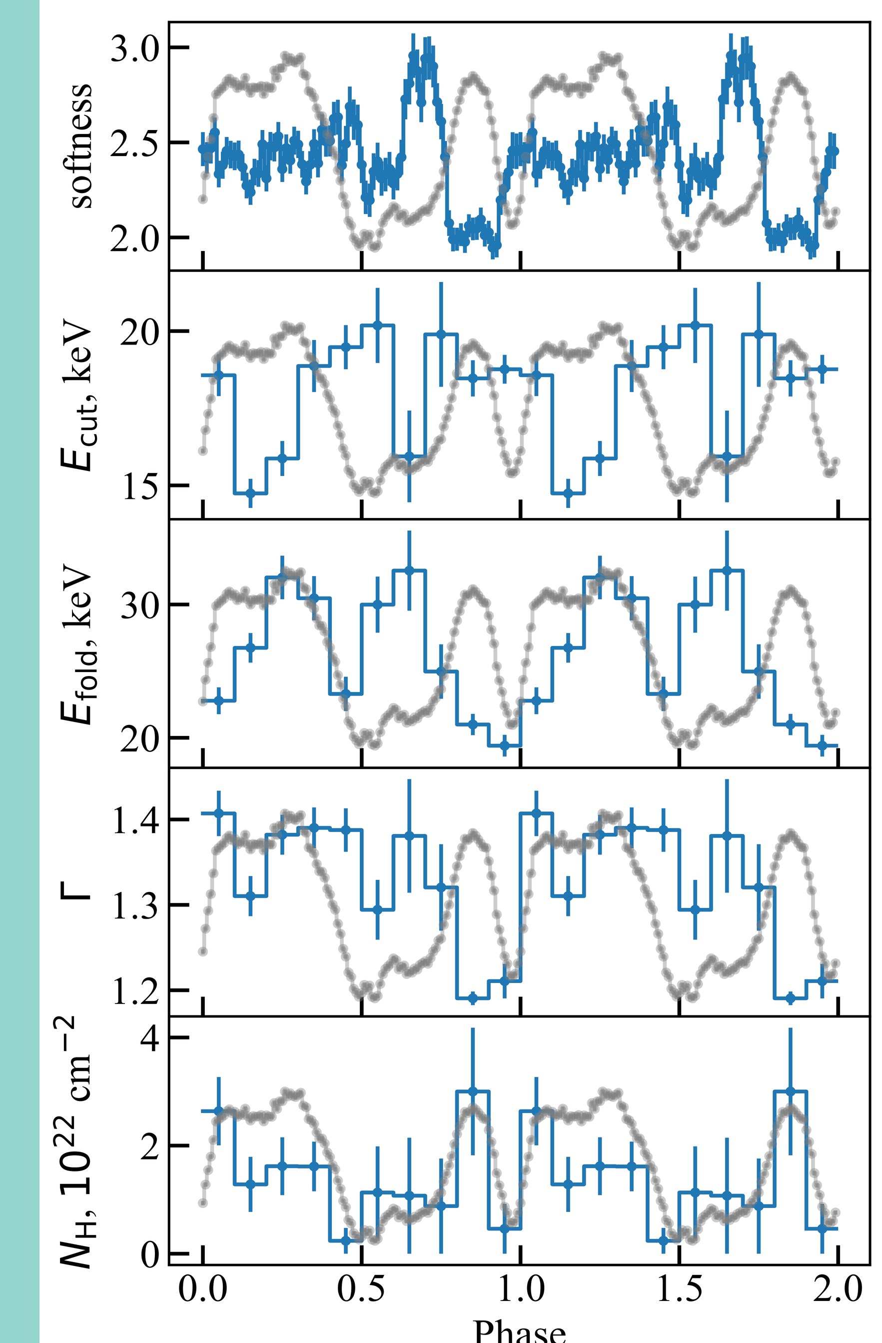
We have proposed and studied new possible candidates for optical companions of XTE J1859+083 and the most likely candidate was identified. The results of photometry and spectroscopy of these possible companions showed that the system is a Be X-ray binary, showing Brγ, He I and strong Hα spectral lines.

Phase-averaged spectrum



Panel a: Unfolded spectrum and its approximation with the model CONST×TBABS×(GABS×PO×HIGHECUT+GAUSS).
Red and black crosses show the data from the *NuSTAR*/FPMA and *NuSTAR*/FPMB, respectively; blue crosses are for the *Swift*/XRT.
The lower three panels show the deviations of the data from the models of different continua.

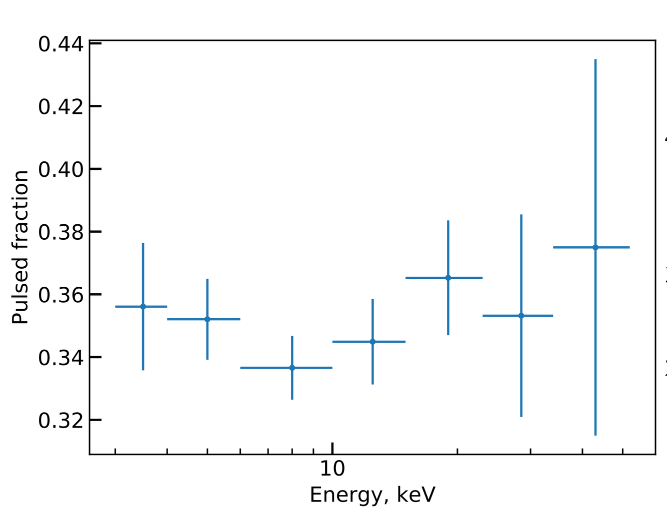
Phase-resolved spectroscopy



The softness ratio of the XTE J1859+083 and the evolution of the spectral model parameters as a function of the spin phase. The averaged pulse profile in a wide energy range is superimposed in gray for visual comparison.

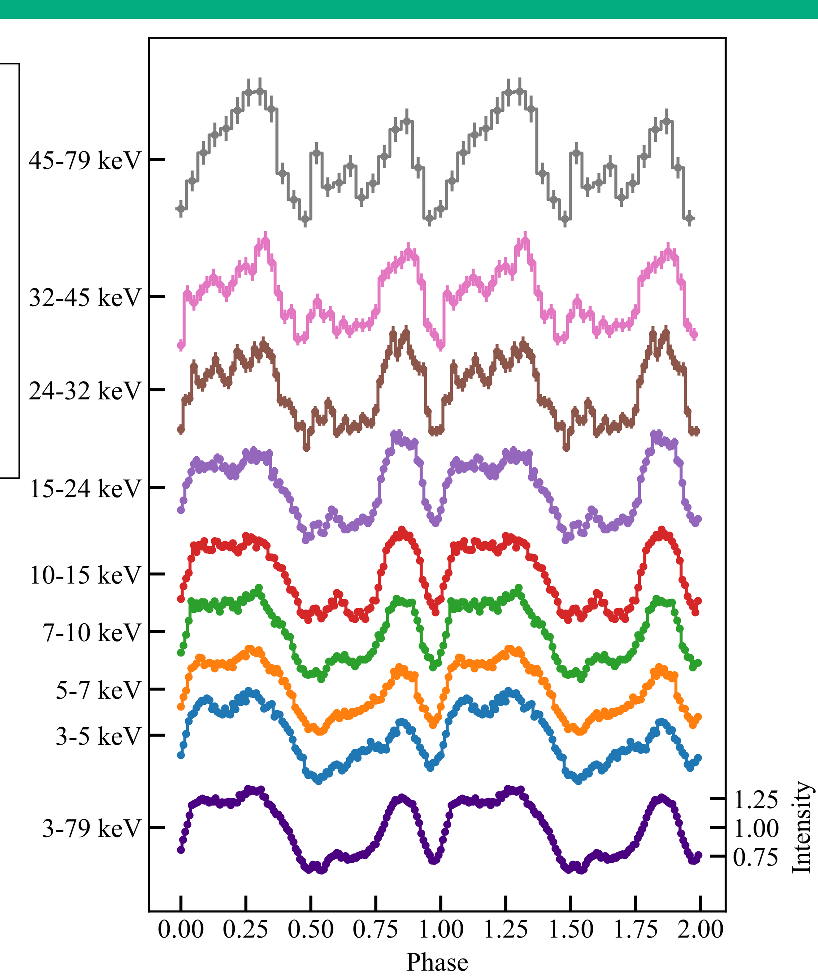
Softness defined as fraction of 3-10 keV / 10-20 keV pulse profiles.

Timing analysis



$$\mathrm{PF} = \frac{I_{max} - I_{min}}{I_{max} + I_{min}}$$

$$P_{spin} = 9.79156 \pm 0.00001 \text{ s}$$



Normalized pulse profiles of XTE J1859+083 in different energy bands according to the *NuSTAR* data.

Optical and IR identification

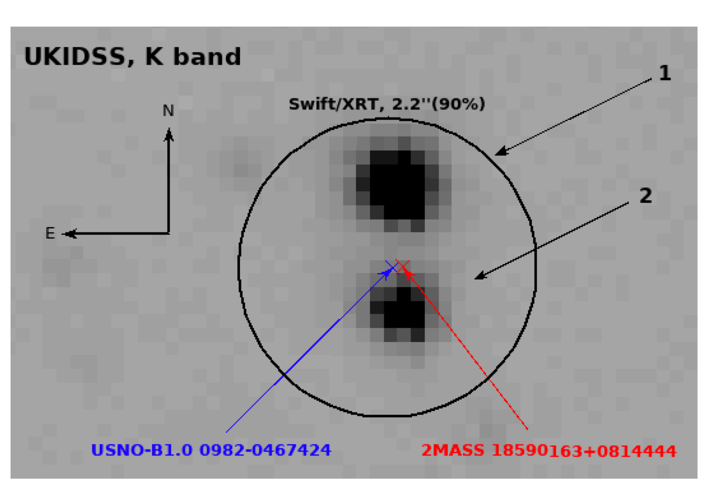
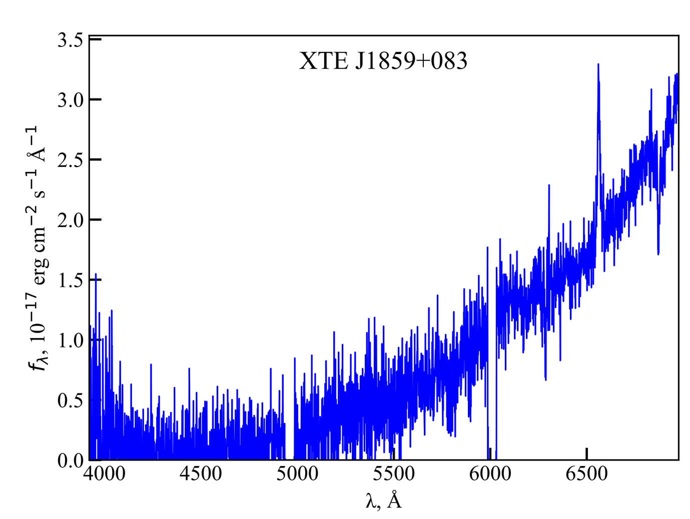


Image of the sky region containing XTE J1859+083 in the K filter according to the UKIDSS sky survey (UKIRT telescope).



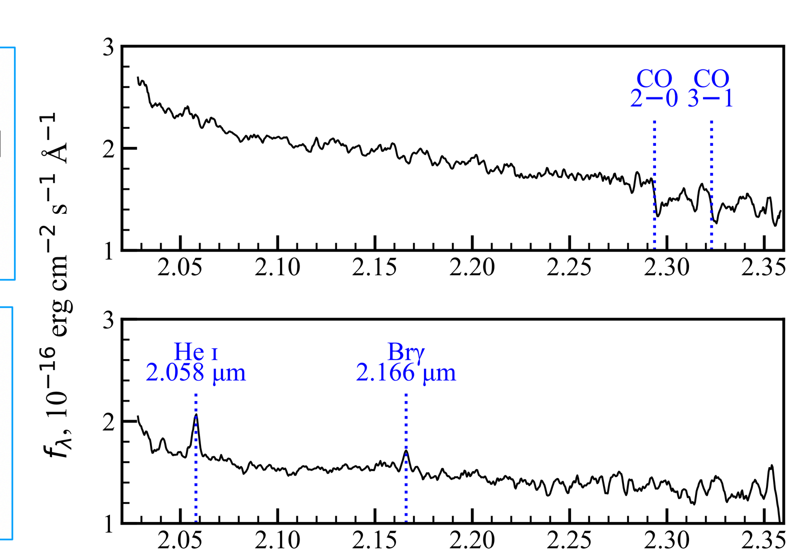
SALT optical spectrum of the combined light of the two candidates for the optical counterpart. **Detection of a strong Hα emission line.**

Star #1 (upper panel)
1) No sign of Brγ emission
2) CO bands at 2.29 and 2.32 μm

→ K or M spectral type

Star #2 (bottom panel)
1) Brγ
2) He I 2.058 μm lines in emission

→ Be-type star (B0-2Ve)



K-band spectra of the two candidates for optical companion.

Conclusions

- Complex energy-dependent shape of pulse profile
- PF has constant value ~ 35%
- No cyclotron absorption line
- $B < 5 \times 10^{11}$ G or 5×10^{12} G $< B < 2.0^{+0.9}_{-1.2} \times 10^{13}$ G
- Brγ, He I and strong Hα spectral lines
- XTE J1859+083 is Be X-ray binary
- star #2 is the most likely candidate, distance is $8.7^{3.6}_{-5.1}$ kpc

ACKNOWLEDGEMENTS:

This research was supported by the grant 14.W03.31.0021 of the Ministry of Science and Higher Education of the Russian Federation. The SALT observations were obtained under the SALT Large Science Programme on transients (2018-2-LSP-001; PI: DAHB) which is also supported by Poland under grant MNiSW DIR/WK/2016/07. DAHB acknowledges research support from the National Research Foundation. MG is supported by the EU Horizon 2020 research and innovation programme under grant agreement No 101004719.