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X-ray Astronomy Group (AIP)

The isolated neutron star 4XMM J022141.5-735632

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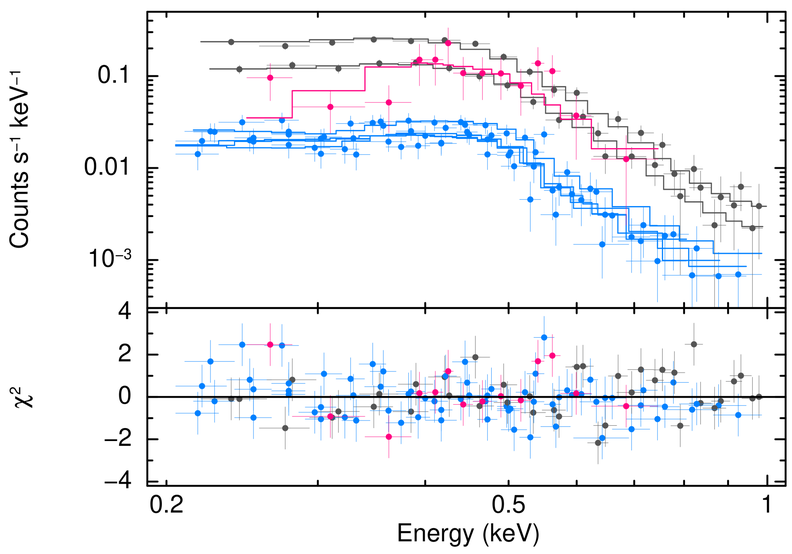
Background

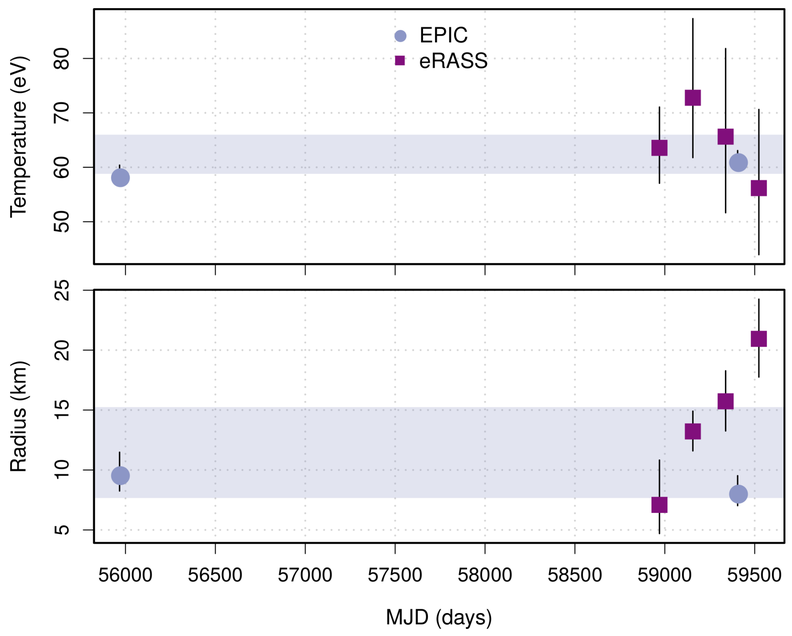
We report the results of follow-up investigations of a possible new thermally emitting isolated neutron star (INS), 4XMM J022141.5-735632, using observations from XMM-Newton and Spectrum Roentgen Gamma (SRG) eROSITA. The analysis is complemented by Legacy Survey imaging in the optical and near-infrared wavelengths. The X-ray source is the first to be targeted by XMM-Newton in an effort to identify new INS candidates from the 4th generation of the XMM-Newton source catalogue Data Release 9 (4XMM-DR9). The source was put forward by Rigoselli et al. (2022) on the same premise of a soft spectrum and lack of obvious counterparts; it is also a „target of interest“ on dedicated searches in eROSITA All-Sky Survey data.

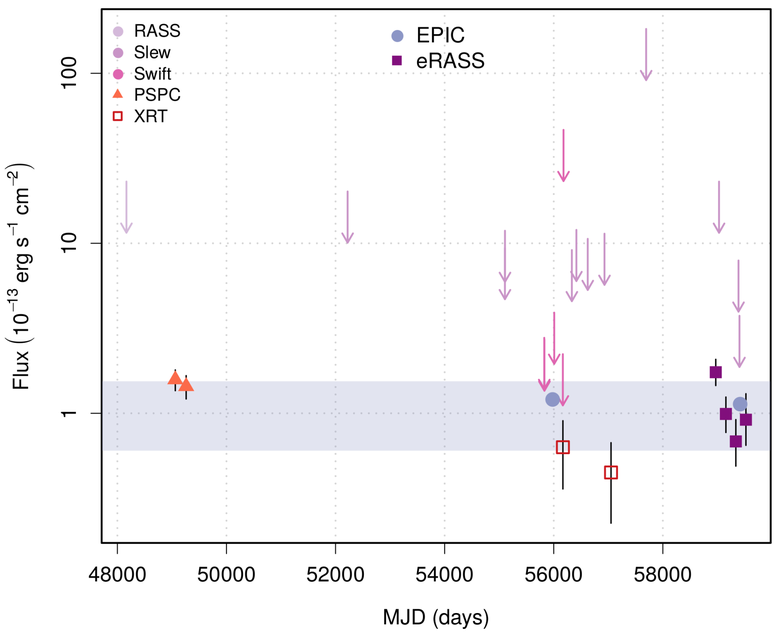
Spectrum and variability

The joint analysis of the XMM-Newton and eROSITA observations performed between 2012 and 2021 confirms the source‘s essentially thermal energy distribution. Excess emission above 0.7 keV may be accommodated with either a second (hot) blackbody or a power-law tail. Magnetised neutron star atmosphere models are also in reasonable agreement with the data.



Best-fit double-blackbody model and residuals. The EPIC pn and MOS data sets are colour-coded in dark grey and blue, respectively, while eROSITA is shown in pink.



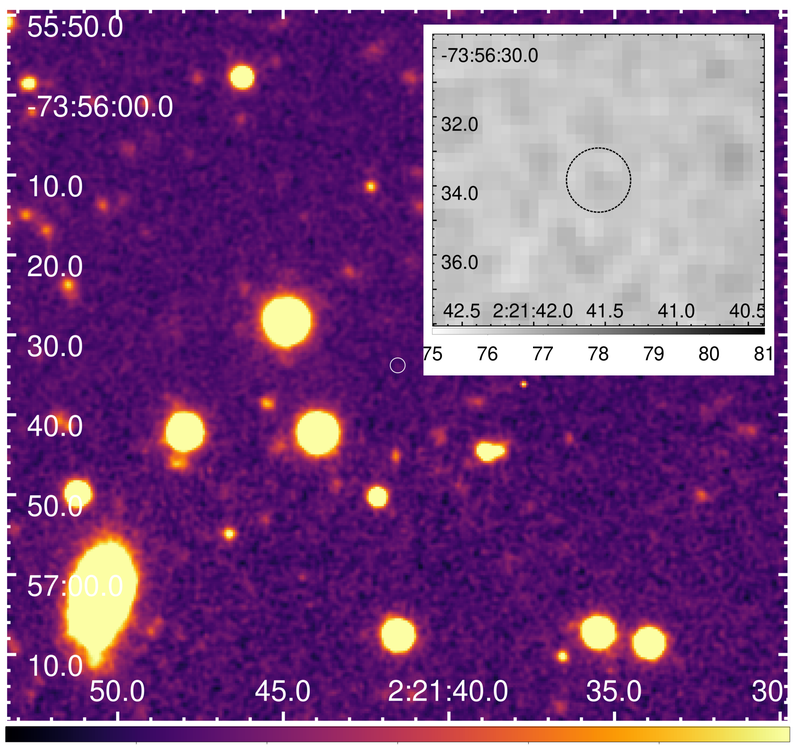


Long-term spectral and flux variation of the X-ray source. Left. Blackbody temperature and emission radius as a function of MJD. Right. Long-term evolution of the 0.2 – 2 keV keV X-ray flux of the target, including upper limits and previous detection by other X-ray missions. The time interval extends back to the ROSAT All-Sky Survey (RASS) and pointed (PSPC) era and include data points from Swift XRT and XMM-Newton slew observations. In all plots the purple horizontal shaded areas show the 1σ median absolute deviation of the parameters.

We find no evidence for variability in either flux or spectral state within the nearly ten-year interval covered by the analysis. Previous detection at a similar flux level suggest that the emission is fairly stable over decade-long time scales.

Optical and nIR limits

Isolated neutron stars are extremely faint in the optical and near infrared. The optical limit derived from the deep stacked Legacy Survey DR10 and DECam images excludes a cataclysmic variable or hot white dwarf in the foreground of the Magellanic Bridge.



Photometric-weighted multi-filter stack of Legacy Survey DR10 (Dey et al. 2019) g, r, z and DECam u, i images centred on the sky position of 4XMM J022141.5-735632. The blank (m_G > 26.45) 3σ confidence level error circle of the X-ray source is displayed in the inset in an inverted black and white colour map.

Summary and Outlook

Thermally emitting INSs are extremely elusive and difficult to detect, especially at faint X-ray fluxes. Yet, they may be as numerous as ordinary pulsars. The discovery of similar sources beyond our local volume is key to understanding their properties as a group and relations to other families of Galactic INSs.

Within current observational limits, the identification of 4XMM J022141.5-735632 with an INS appears robust. Future observations, particularly to search for pulsations, are crucial to shed further light on the nature of the X-ray source and relations to other Galactic neutron stars.

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References

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