POST-EXTRAS DISCOVERY OF A NEW CANDIDATE MAGNETAR IN THE LMC

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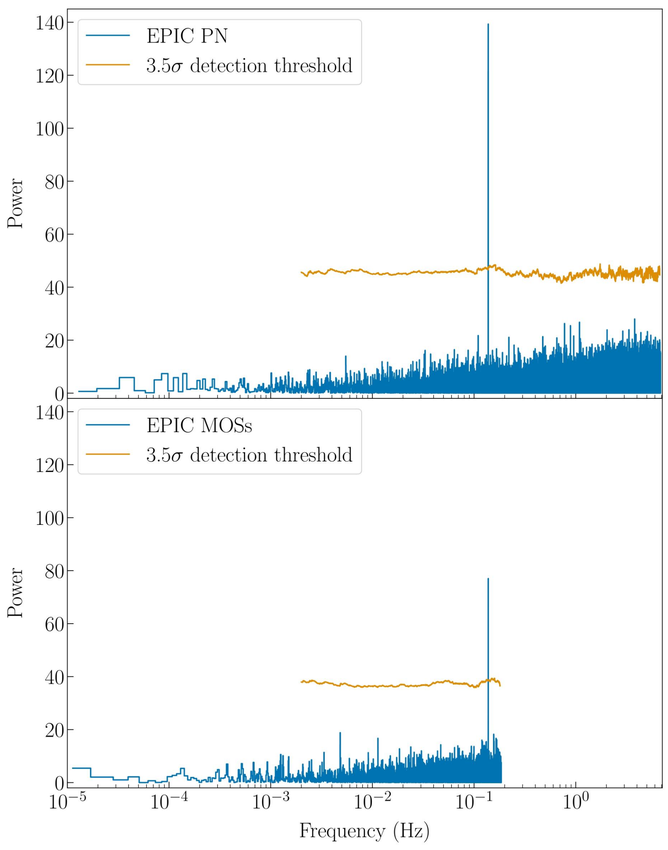
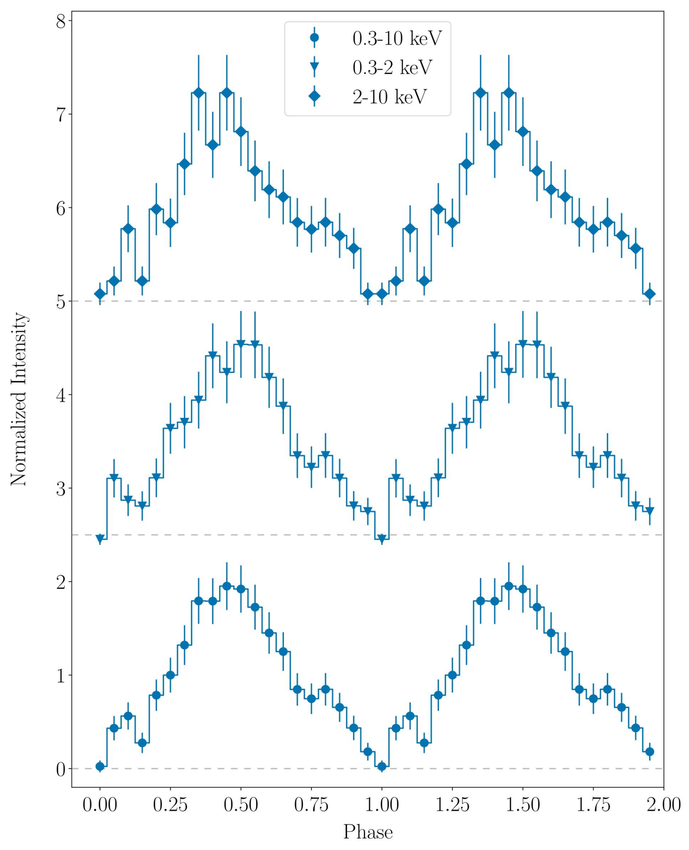
J0456: THE DISCOVERY OF THE SPIN PULSATION

- The **Exploring the X-ray Transient and variable Sky** (EXTraS; De Luca et al., 2021) project is the **most thorough search for new pulsators in the XMM-Newton archive**. The pipeline is routinely applied to the newly public data (post-EXTraS phase).

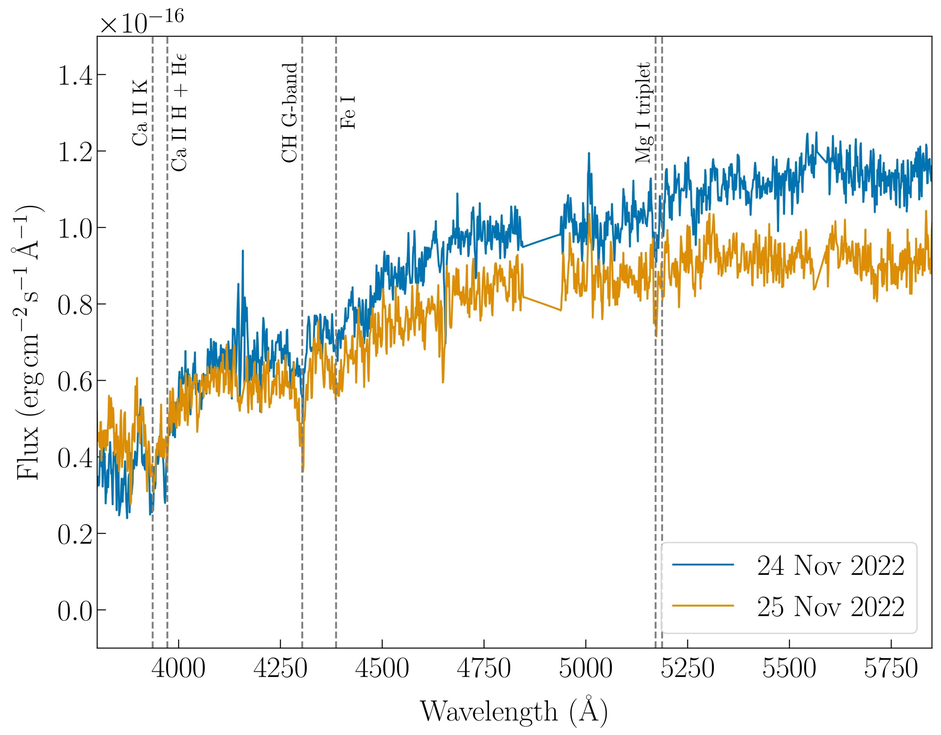
- We detected a **periodic signal at P = 7.25 s** from 4XMM J045626.3-694723 (J0456), in the direction of the Large Magellanic Cloud (LMC). Given the timescale of the pulsation, **J0456 is most likely a spinning neutron star**. Despite the field being observed 6 times by XMM-Newton and other X-ray telescopes, this is the only detection of J0456.

- The signal has a pulsed fraction **PF = (86 ± 6) %**. No apparent evolution in the 0.3 - 10 keV range. Minimum consistent with zero-flux level. Possible self-occultation.



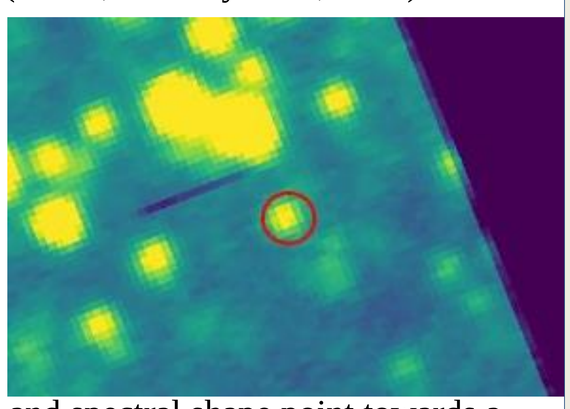


SALT OBSERVATIONS OF A CANDIDATE OPTICAL COUNTERPART



- The **vast majority of variable neutron stars in the LMC** emitting in the X-ray band is **found in BeXRBs** (see e.g. Antoniou & Zezas, 2016), binary systems in which the neutron star is accreting matter from a massive, O/Be-type star.

- We identified a **candidate optical counterpart** within the 3σ uncertainty region of XMM-Newton. We observed this source with the 11-m **Southern African Large Telescope** (SALT; Buckley et al., 2006) for a total of **6000 s splitted in two consecutive nights**.



- Radial velocity of the detected lines consistent with the star being in the LMC:

  $v_r \sim 250$ km/s

- Absolute magnitude ($M_V \sim 0.2$ mag) and spectral shape point towards a G/K-type star. **If confirmed, this would be the first X-ray binary of its kind in the LMC**. However, a **high chance coincidence probability challenges the XRB scenario**.

A NEW CANDIDATE MAGNETAR IN THE LMC?

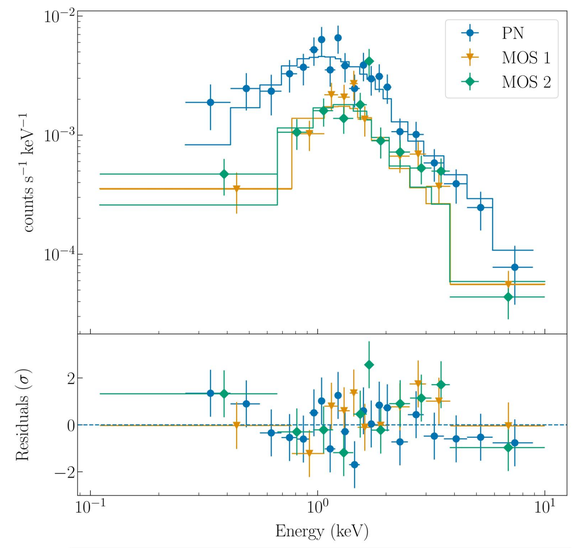
- What if **J0456 is isolated**?

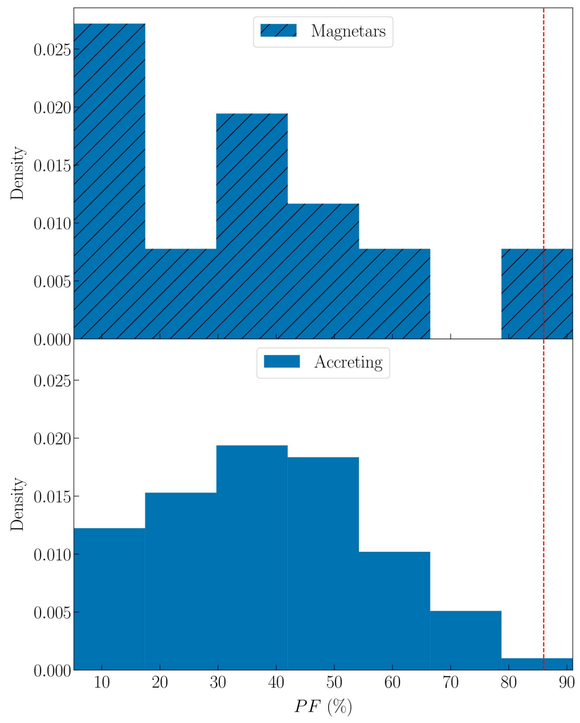
- Simple power-law spectrum. Assuming the LMC distance of 50 kpc:

$N_H \simeq 4.8 \times 10^{21}$ cm^{-2}

$\Gamma \simeq 1.95$

$L_X \simeq 2.73 \times 10^{34}$ erg s^{-1}





- X-ray luminosity particularly low for an accreting neutron star with P ≃ 7.25 s. On the other hand, **if isolated, J0456's luminosity is perfectly in line with that of a magnetar for which we missed the onset of an outburst**.

- A **high pulsed fraction is much more common in magnetars** than in accreting neutron stars.

- eROSITA upper limit 6 months later in line with decaying phase of a magnetar outburst.

SWIFT MONITORING PROGRAMME AND CONCLUSIONS

- From February 2023 to July 2024 **we monitored J0456 with Swift**, hoping to detect the source in an active state and trigger further observations. As of now, **we do not have a second detection of the source**.

- Assuming that J0456 has entered a quiescent state that does not change over time and assuming spectral parameters similar to the one we derived in our paper, **we can merge all the observations of our Swift monitoring programme and set a 3σ upper limit on the unabsorbed flux** in the 0.3-10 keV band:

$F_X \lesssim 5 \times 10^{-14}$ erg cm^{-2} s^{-1}

- At the moment, **we favour the magnetar scenario**. A new detection during the active state could help us solve the mistery of the nature of J0456.

SCAN ME