



Leibniz-Institut für
Astrophysik Potsdam



eRO-STEP
FOR2990



New thermally emitting isolated neutron stars from SRG/eROSITA

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In collaboration with:

Axel Schwobe, Adriana M. Pires, Frank Haberl

The X-ray mysteries of neutron stars and white dwarfs, 05.06.2024

The known X-ray dim isolated neutron star population

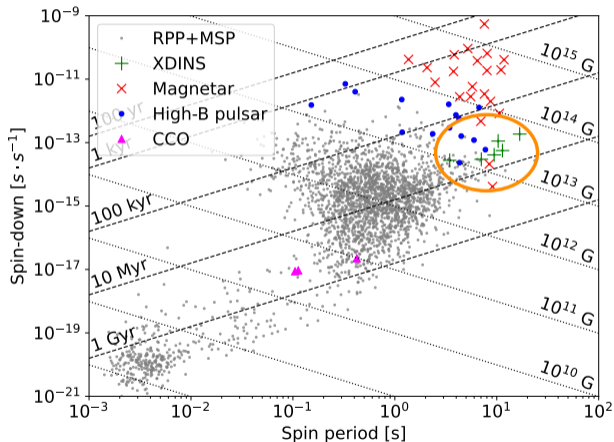
7 XDINSs known (Magnificent Seven)

Characteristics:

- Predominantly thermal emission
- Radio-quiet
- Nearby (within 1 kpc of sun)
- Larger magnetic field strengths, spin periods and thermal luminosities than "ordinary" RPPs

Interesting population properties:

- Locally as common as RPPs
- Evolutionary connection to magnetars proposed



The search for new XDINSs

XDINSs are best observed at soft X-rays

Searches ongoing since initial discovery

- ROSAT (Rutledge+2008; Demasi+2024)

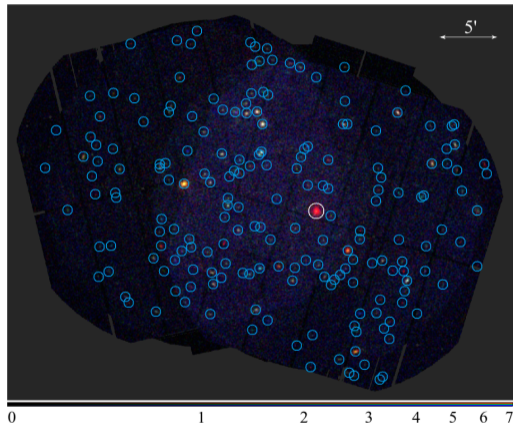
- XMM (Pires+2008,2022; Rigoselli+2022)

→ Source confusion/limited sky coverage
affects search

Population synthesis models:

~ 25 XDINSs in eROSITA

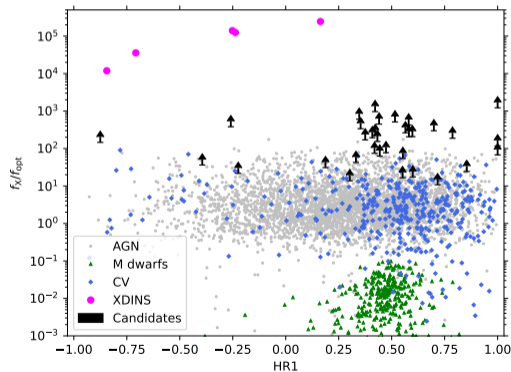
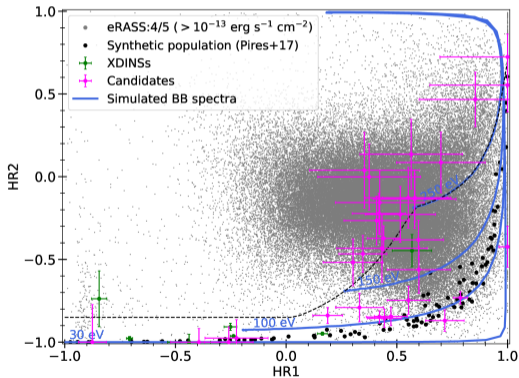
($\log(F_x) > -13$, 0.2 – 2 keV; Pires+17)



Pires, et al., 2022, A&A, 666, A148.

Candidate selection

Goal: Search the SRG/eROSITA All-Sky Survey for XDINSs to compose a flux-limited sample ($f_X > 10^{-13}$ erg s $^{-1}$ cm $^{-2}$, 0.2 – 2 keV)



The candidate sample and follow-up

33 candidates survive the selection

→ 13 soft ($kT \lesssim 150$ eV)

→ 20 harder ($kT \gtrsim 200$ eV, $\Gamma \sim 1 - 4$)

→ 1 - 3 new XDINSs may be expected

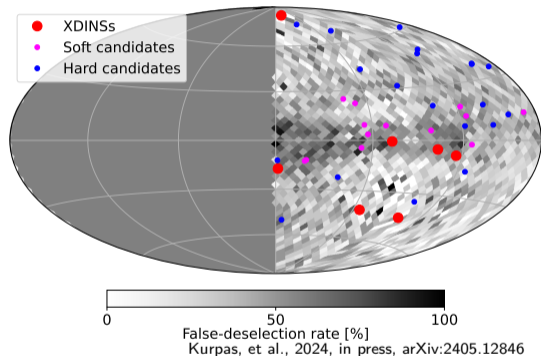
Paper in press (Kurpas+24, arXiv:2405.12846)

Follow-up needed to confirm INS nature!

→ XMM-Newton, NICER, Chandra:
spectrum, position, pulsations

→ LBT, SALT and VLT: f_x/f_{opt}

→ FAST: pulsations



The candidate eRASSU J065715.3+260428

Recently targeted with XMM-Newton (67 ks),
NICER (220 ks), VLT (1 h), and FAST (5 h)

Optical:

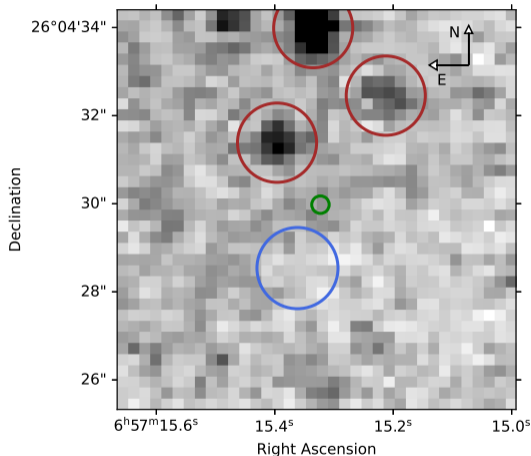
→ $m_{R,lim} = 27.3$ mag, $f_X/f_{opt} \gtrsim 5200$

X-ray:

→ Preliminary timing solution: $P \approx 261$ ms,
 $\dot{P} \sim 10^{-14}$ s s $^{-1}$

→ Thermal spectrum (~ 90 eV, ~ 220 eV) +
absorption feature (~ 300 eV)

FAST: No pulsation down to $1.4 \mu\text{Jy}$ (10σ)



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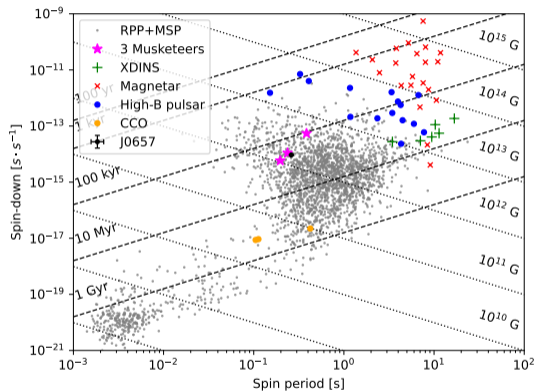
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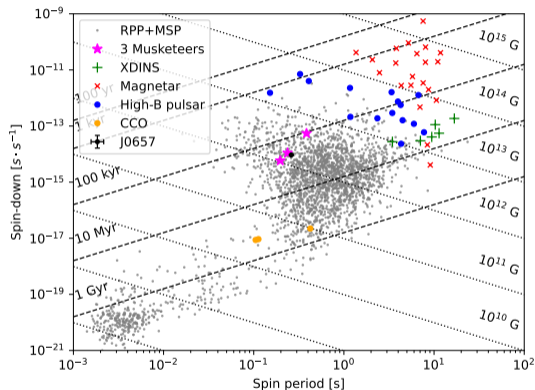
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→ Thermal spectrum (~ 90 eV, ~ 220 eV) +
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A radio-quiet intermediately-aged RPP?

The candidate eRASSU J131716.9–402647

Recently targeted with XMM-Newton (37 ks),
NICER (49 ks), and VLT (1.7 h)

Optical:

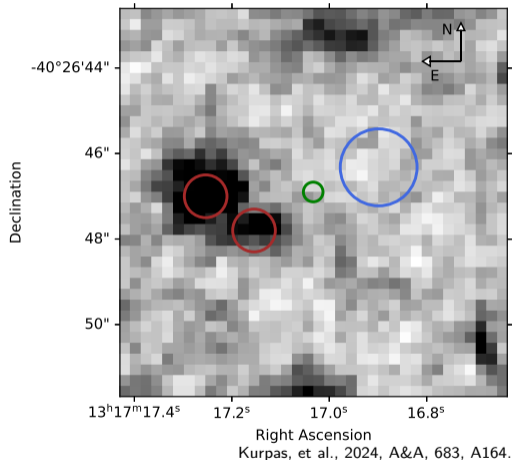
→ $m_{R,lim} = 27.5$ mag, $\log(f_X/f_{opt}) \gtrsim 4$

X-ray:

→ Timing: $P \approx 12.76$ s, $\dot{P} \leq 8 \times 10^{-11}$ s s⁻¹

→ Thermal spectrum (~ 95 eV) +
2 absorption features (~ 260 eV, ~ 590 eV)

Relatively strong X-ray luminosity



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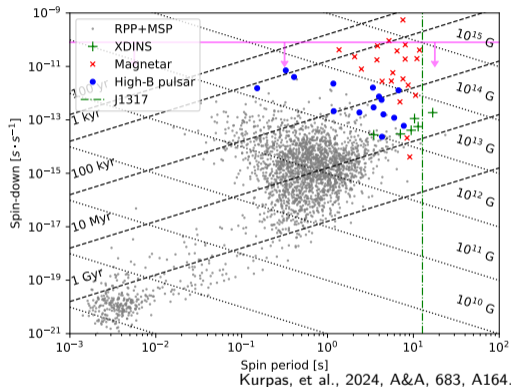
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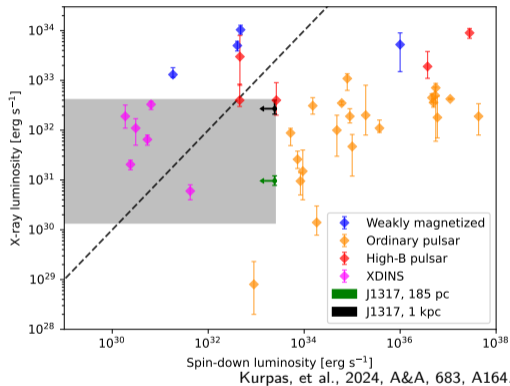
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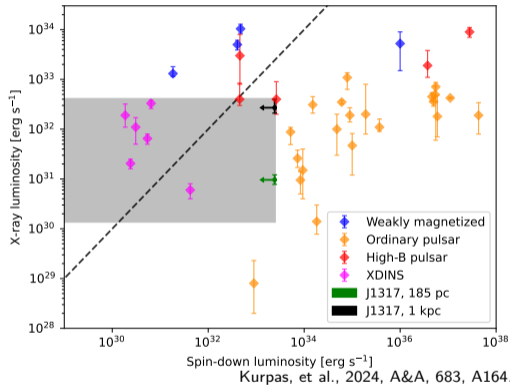
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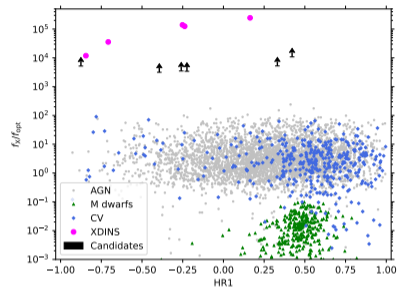
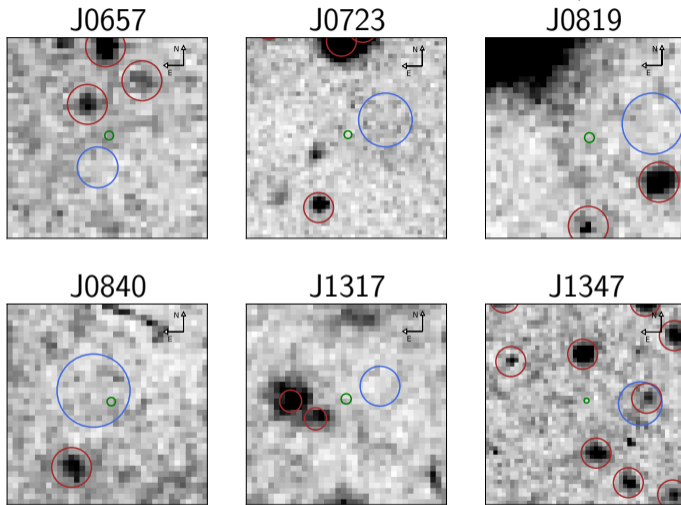
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Relatively strong X-ray luminosity



Highly magnetised INS, conforms well with XDINSs!

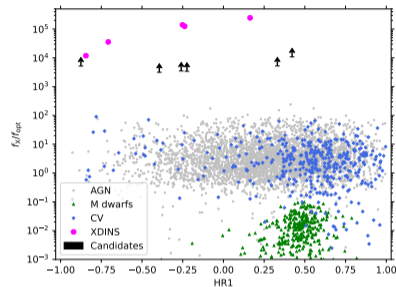
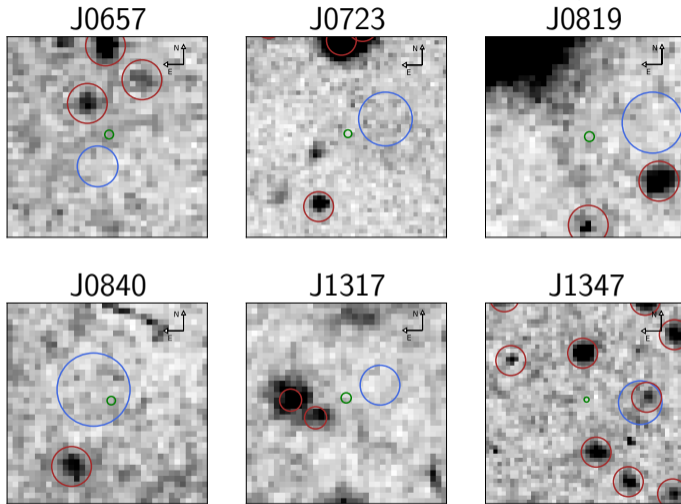
The whole XMM-Newton/VLT large programme



7 sources observed in AO22
→ 6 new thermally emitting
INSs!

Soft thermal spectra:
→ $kT \sim 50 - 80$ eV

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Soft thermal spectra:
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SRG/eROSITA is actively increasing the INS population!

Summary

New XDINSs are ought to be hiding in the SRG/eROSITA All-Sky Survey

Identified 33 candidate objects (Kurpas, et al., 2024, in press, arXiv:2405.12846)

→ 13 soft candidates

→ 20 harder sources

Follow-up campaign ongoing

→ A very XDINS like source (J1317; Kurpas, et al., 2024, A&A, 683, A164)

→ A new radio-quiet RPP (J0657; Kurpas, et al., in prep.)

→ At least 4 additional INSs were discovered (Kurpas, et al., in prep.)

To be continued ...