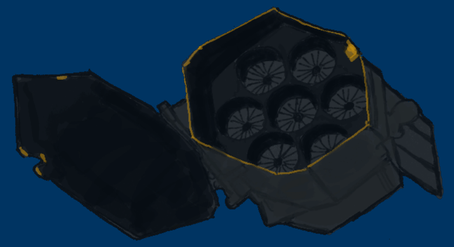


A new HMXB and the puzzles it poses

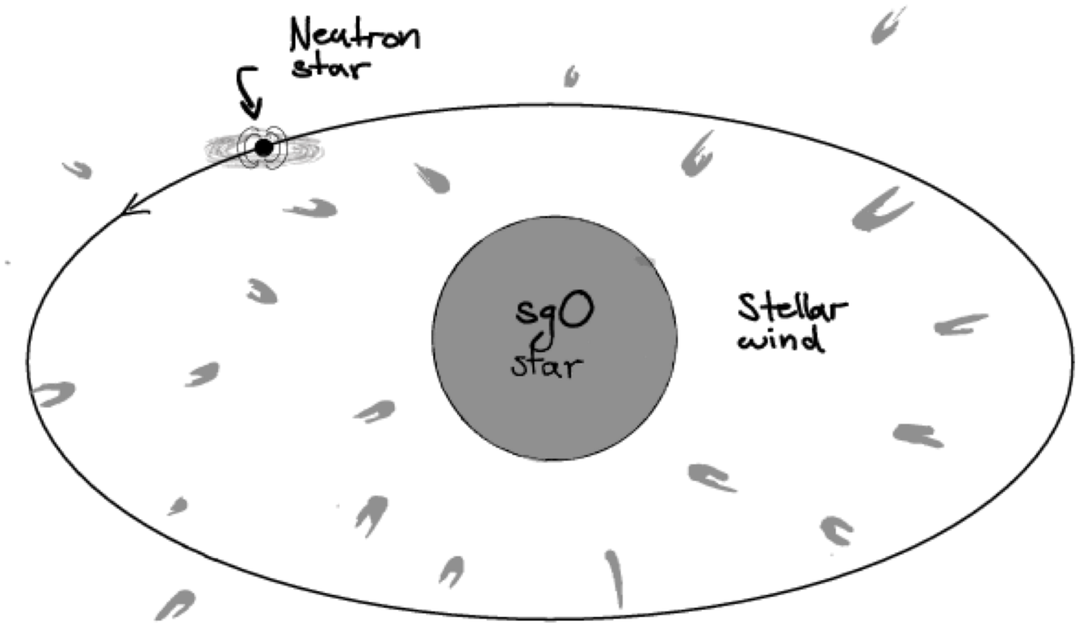
Aafia Zainab, Artur Avakyan, Philipp Thalhammer, Nicolas Zalot, Ekaterina Sokolova-Lapa, Jakob Stierhof, Ralf Ballhausen, Nazma Islam, Peter Kretschmar, Victor Doroshenko, Camille M. Diez, Steven Haemmerich, Rick Rothschild, Katja Pottschmidt, Thomas Duaser, Joern Wilms and many others!

ICE-CSIC, NewAthena Rising, June 2, 2026

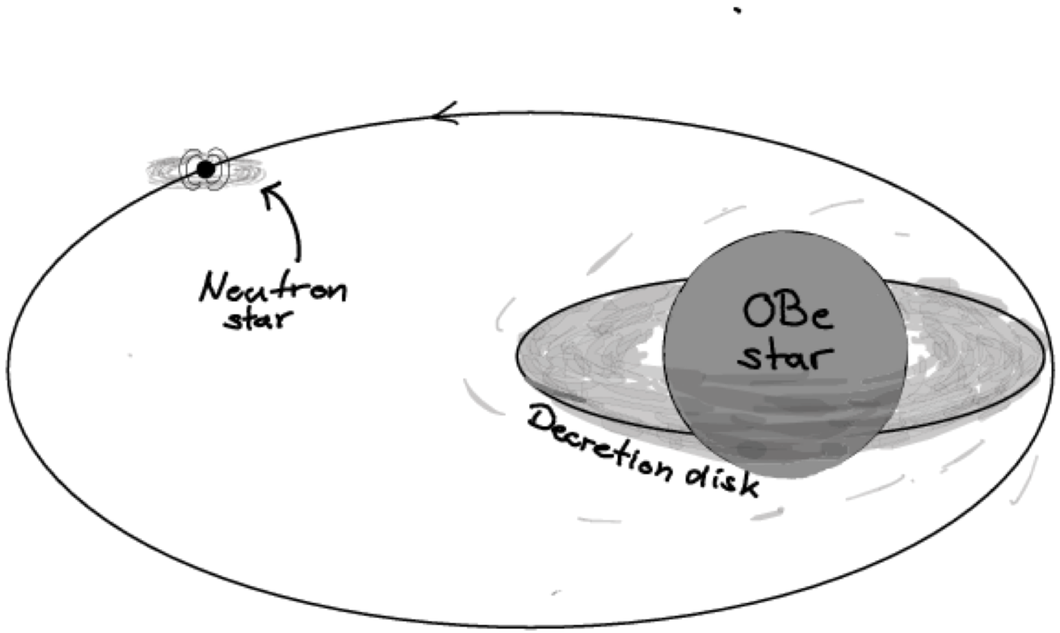
Caption

High Mass X-ray Binaries typically

SGXB



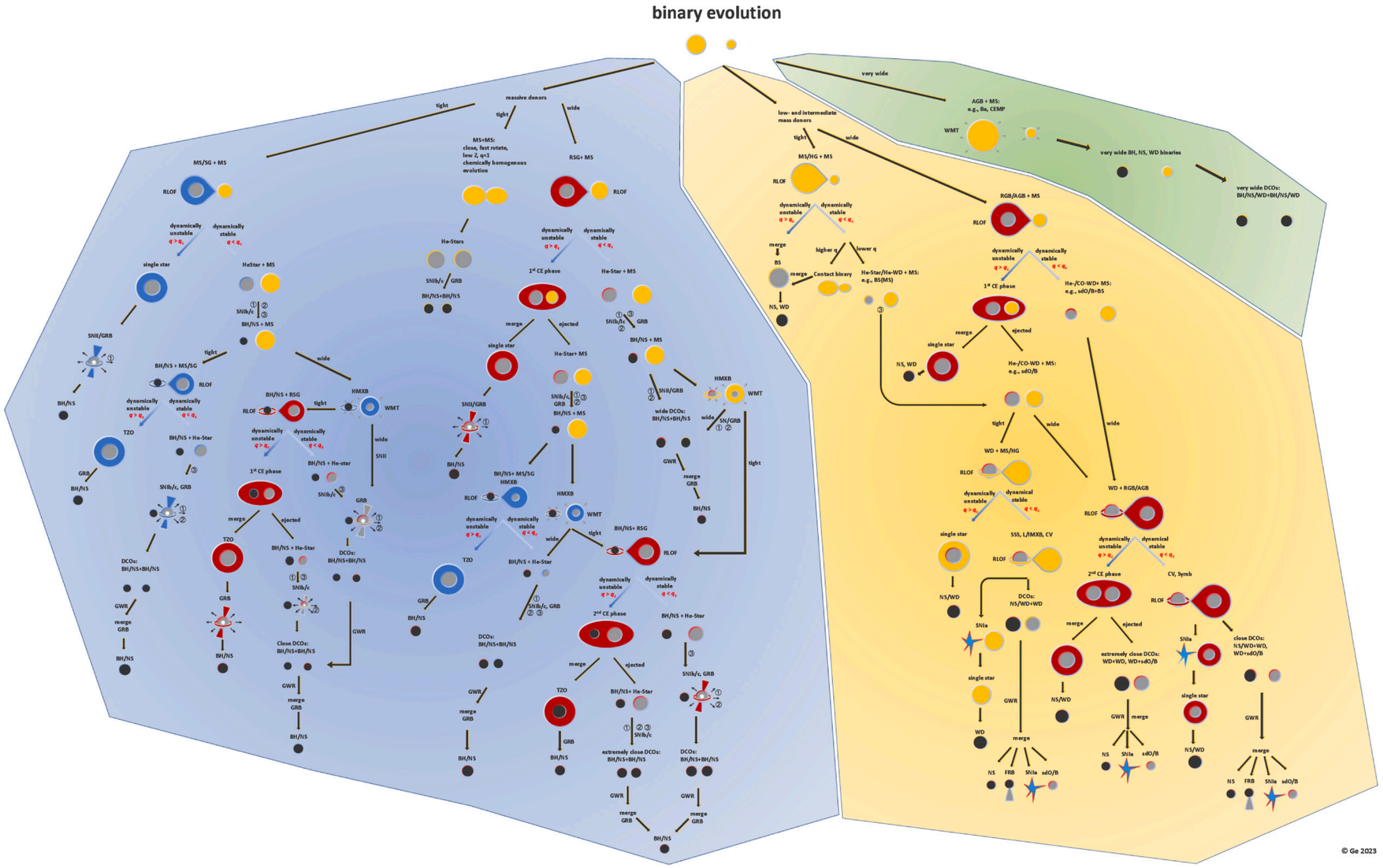
BeXRB



Credit: Philipp Thalhammer, Remeis Observatory

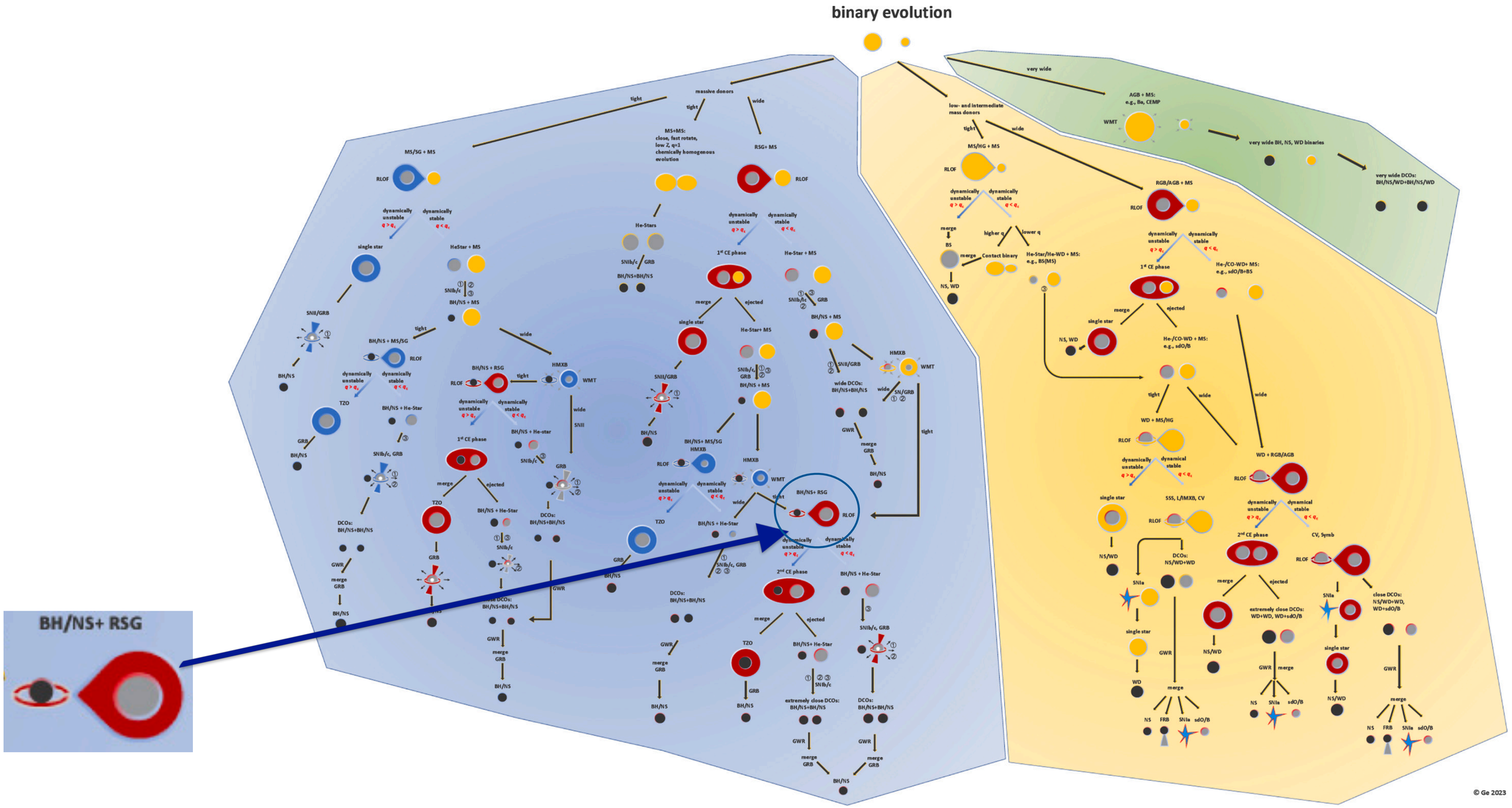
But there are other rarer subtypes: SFXTs, sgB[e]XBs..

But they may take many pathways…



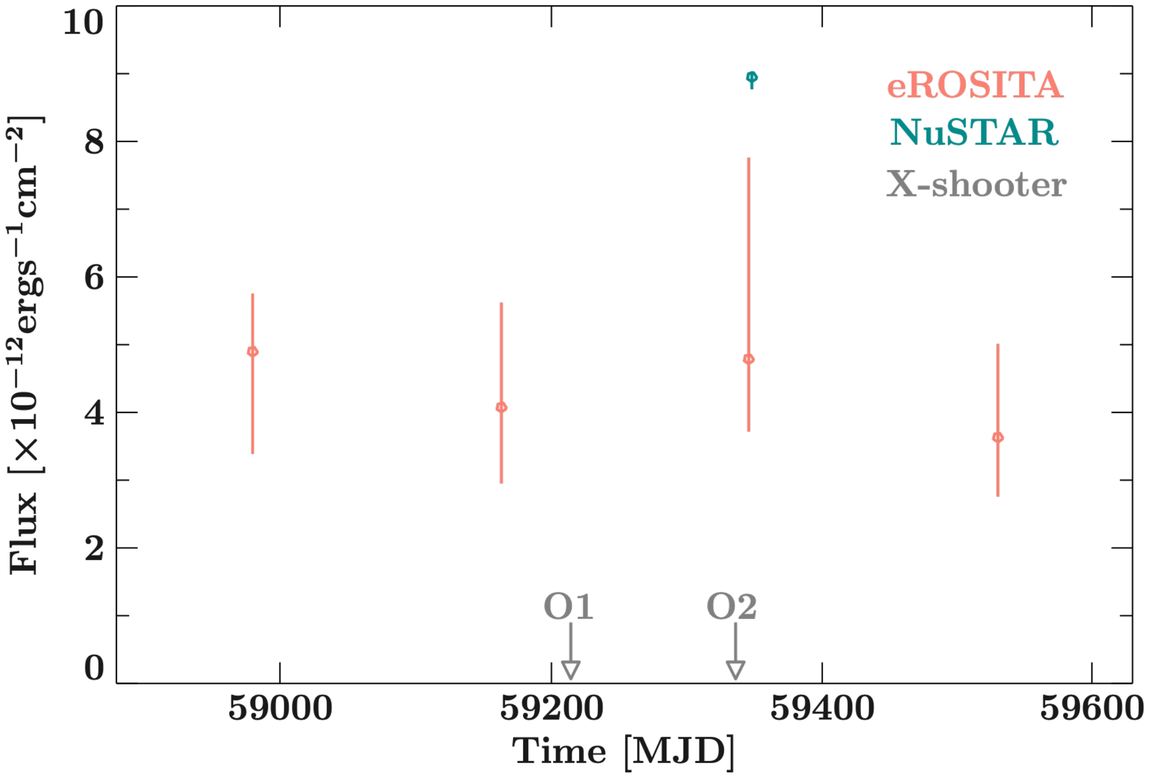
Han+20

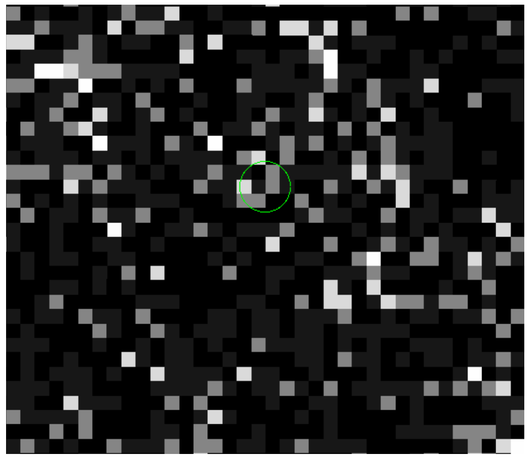
eRASS J085039.9–421151: a rare X-ray Binary with a red supergiant!



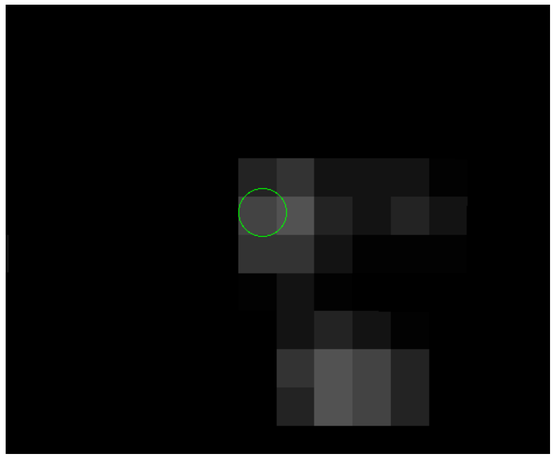
Han+20

A persistent source — discovered in surveys

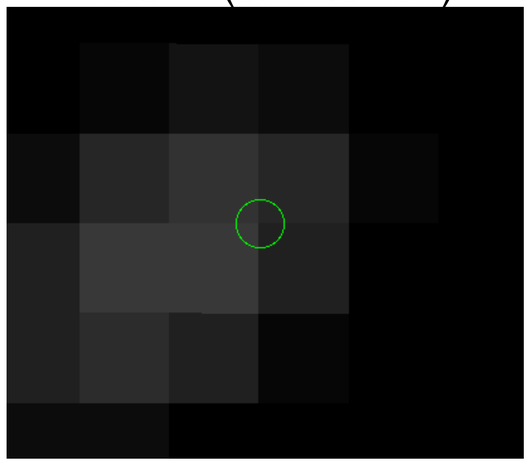




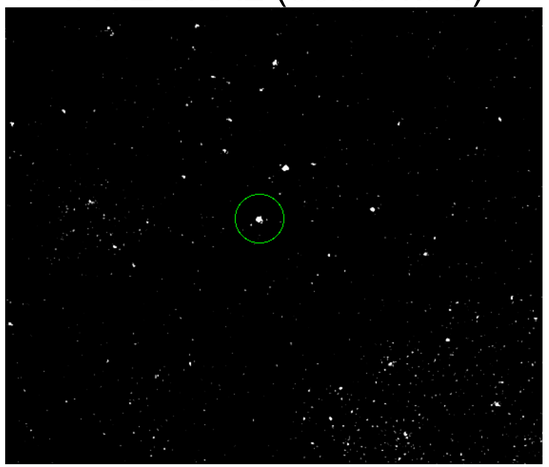
ROSAT (0.2-2.3 keV)



INTEGRAL (30-50 keV)



Swift/BAT (15-190 keV)



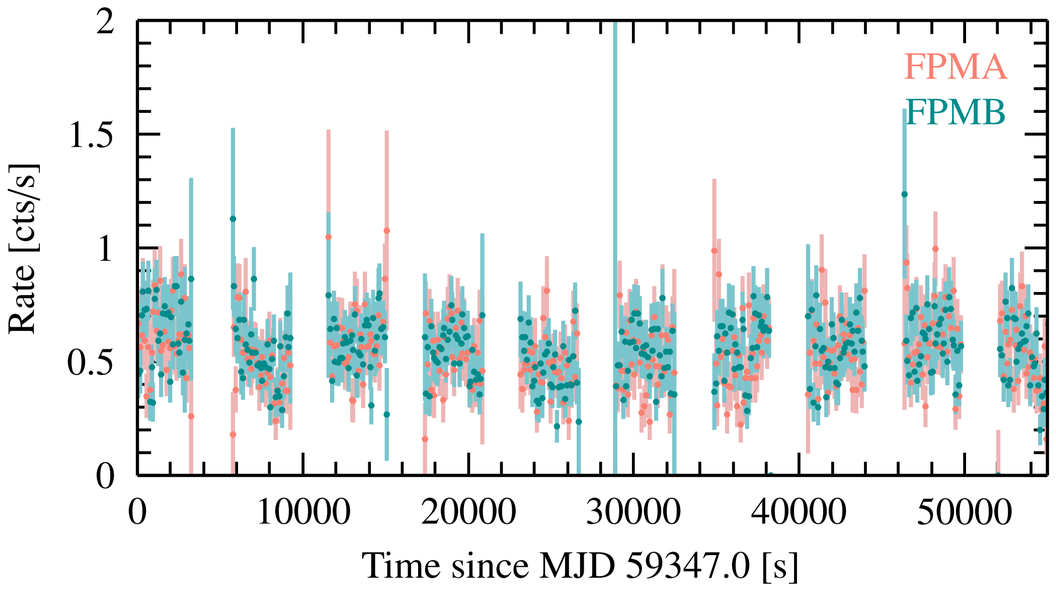
eROSITA (0.2-10 keV)

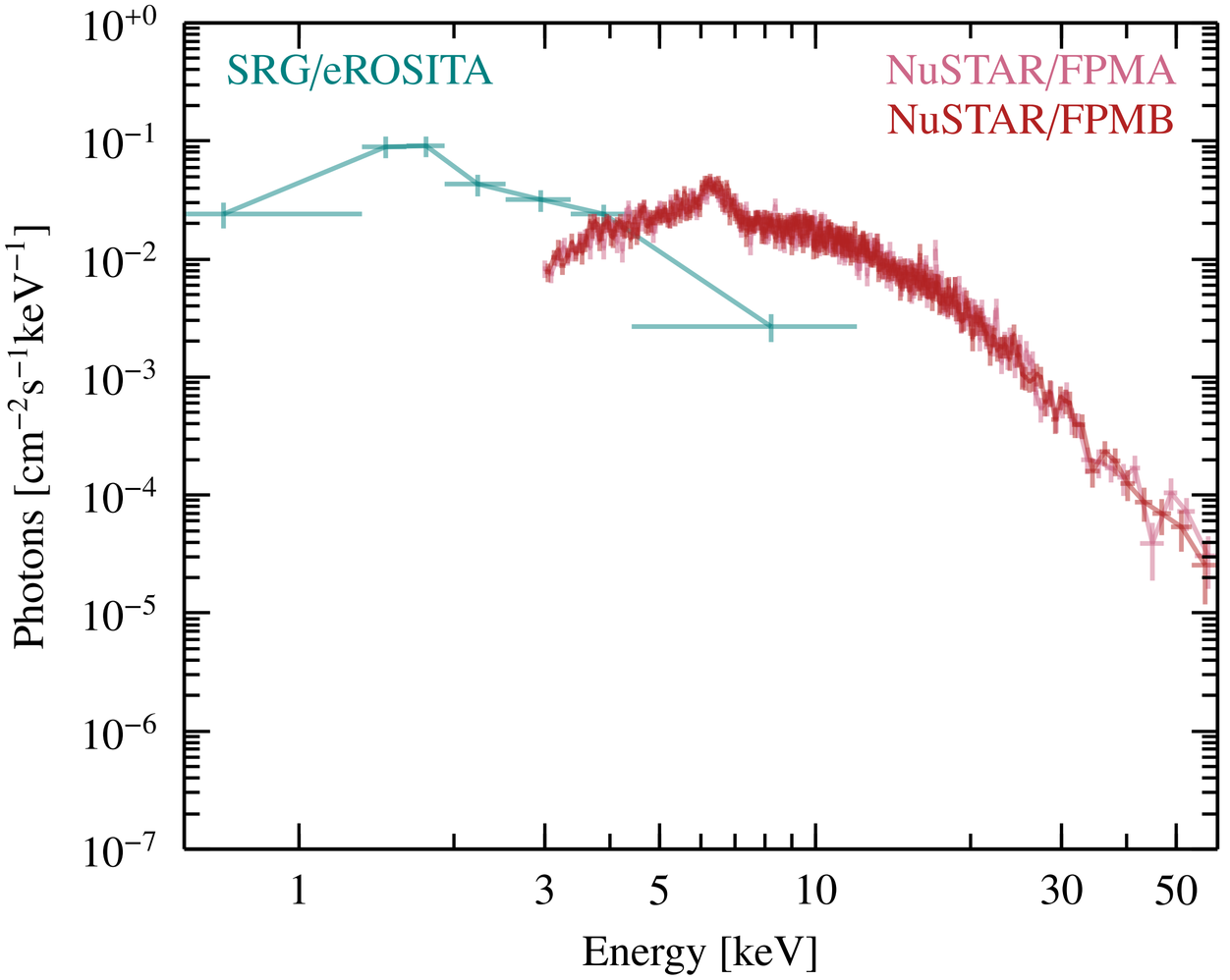
➡Persistent luminosity $L_{\rm X} \sim 10^{35}\,{\rm erg\,s^{-1}}$

Zainab+25

What is the compact object?

- X-ray spectrum fit with a cutoff power law, hard spectrum — so neutron star?
- But no pulsations…
- Intriguing — high Fe Kα equivalent width.





Zainab+25

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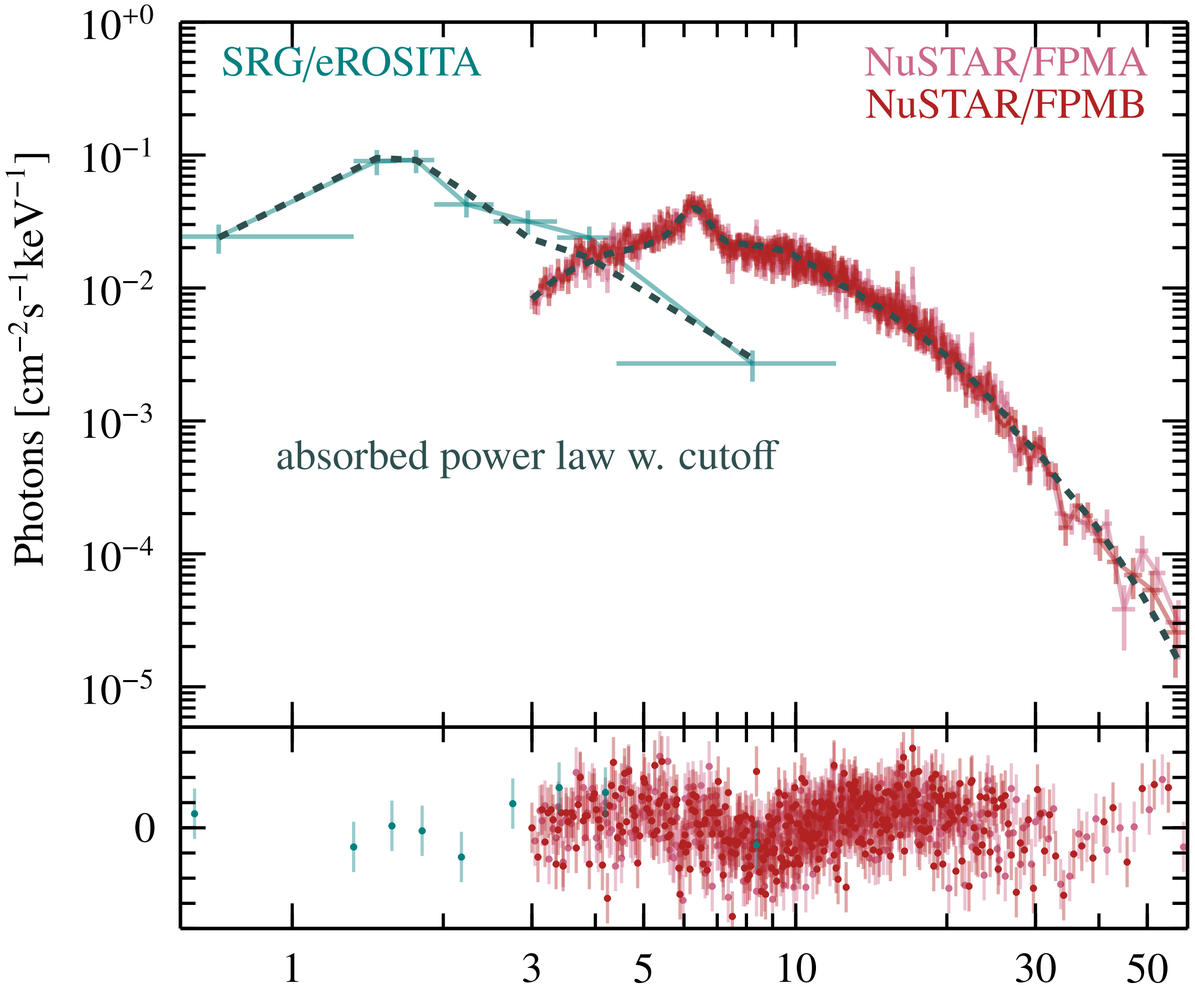
- If neutron star, age and magnetic field a question. Weakly magnetised neutron star — likely in an LMXB.
- Optical spectra —> binary evolution scenarios.



Zainab+25

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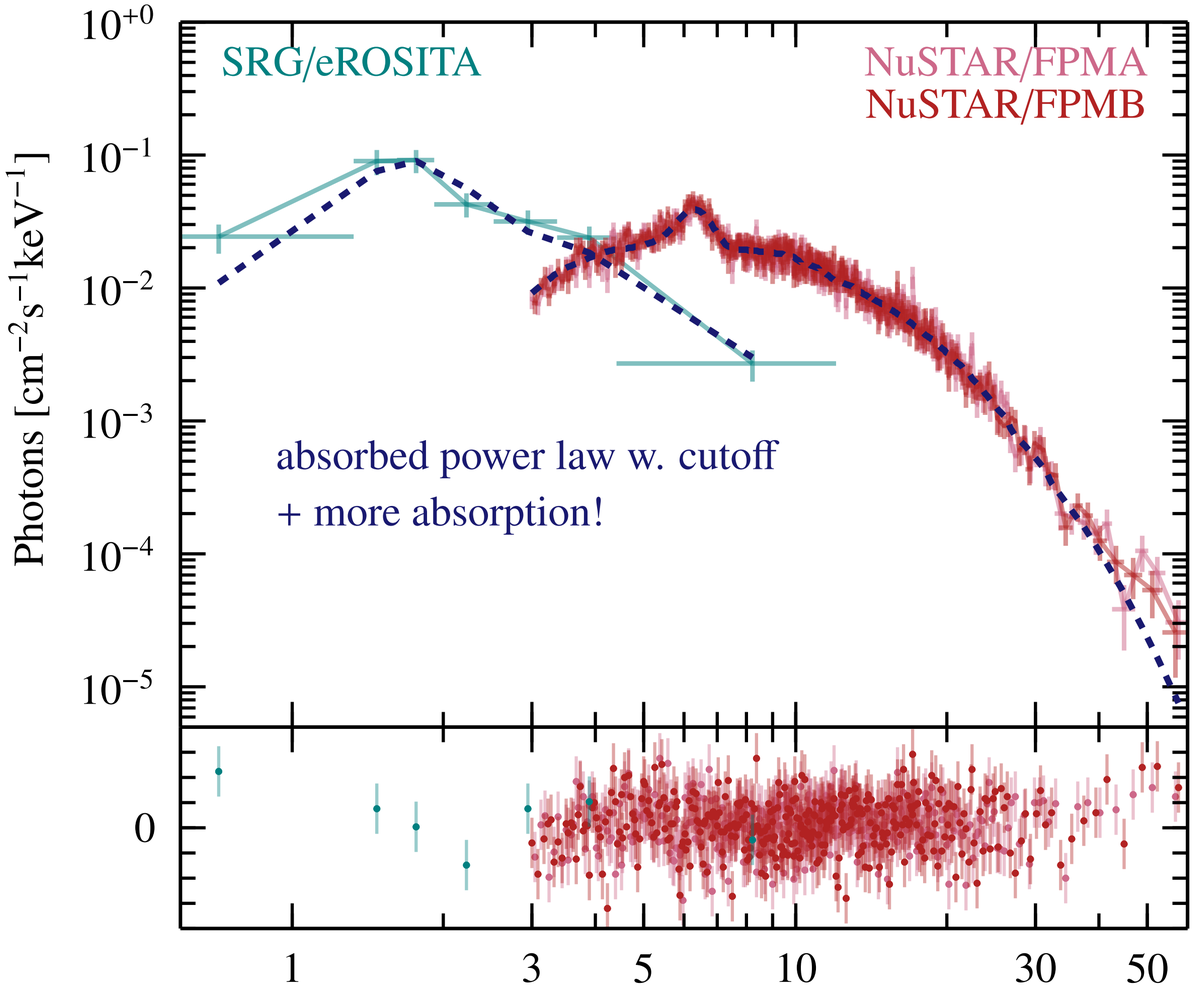
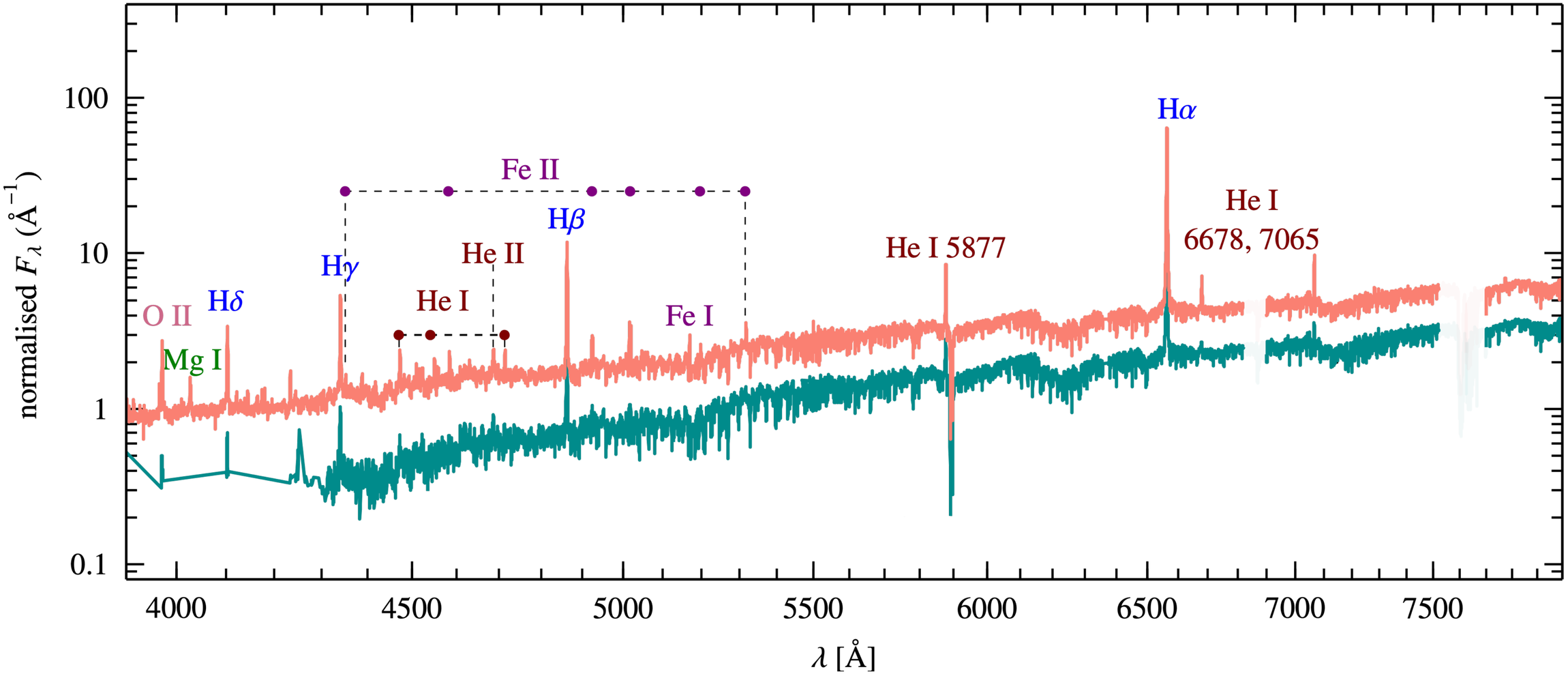


Zainab+25

What is the donor?

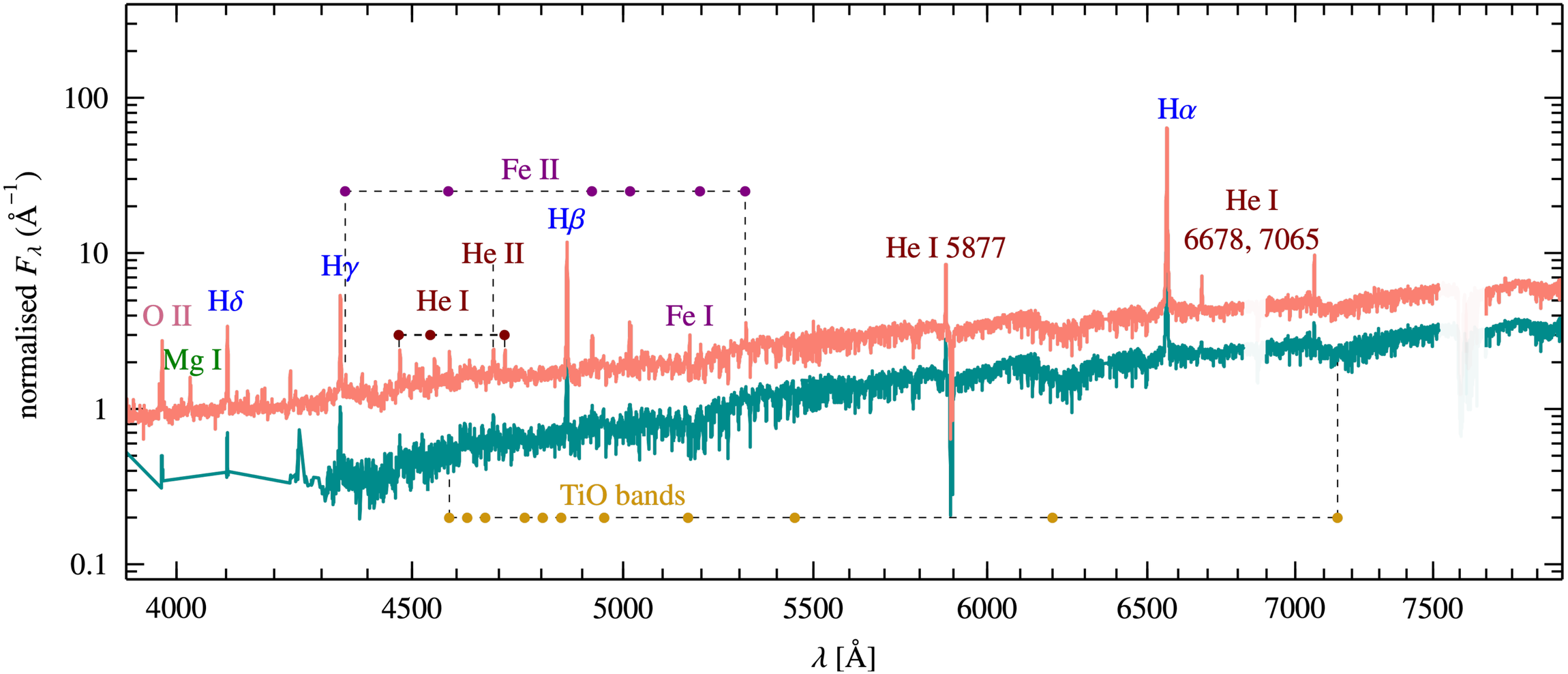


Caption

➡Optical spectrum, with variable emission lines — Be star?

Zainab+25

What is the donor, and where are these lines coming from?!

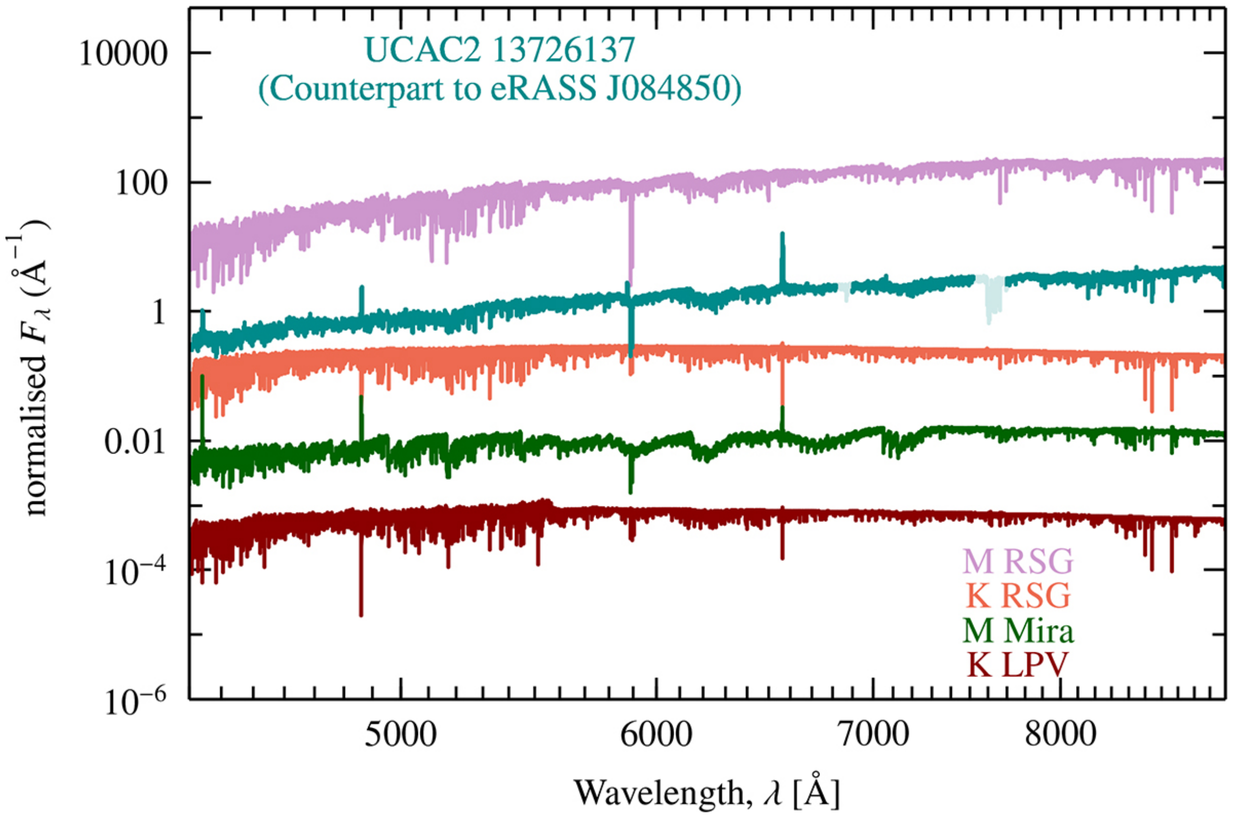


Caption

Zainab+25

- Optical spectrum, with variable emission lines — Be star?
- But TiO bands giveaway for late spectral type

So, *is* the donor a Mira variable?

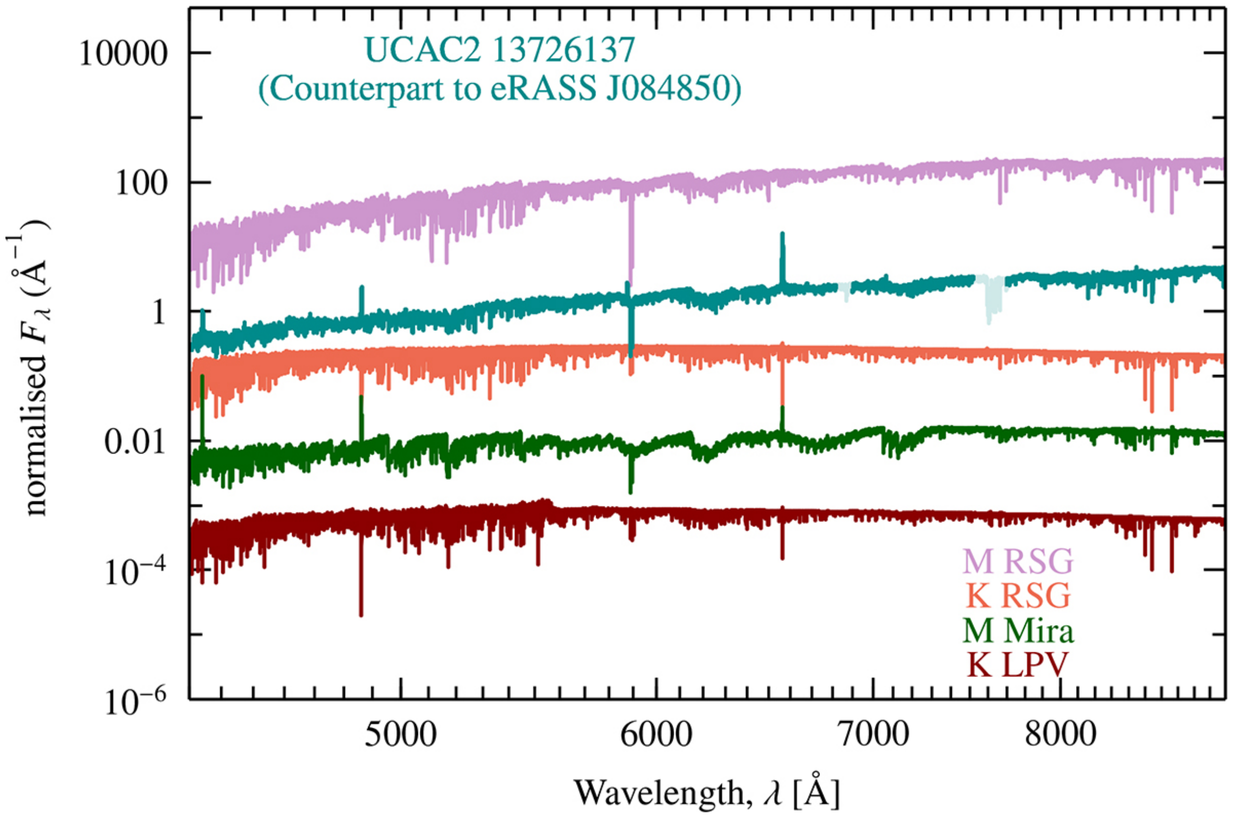


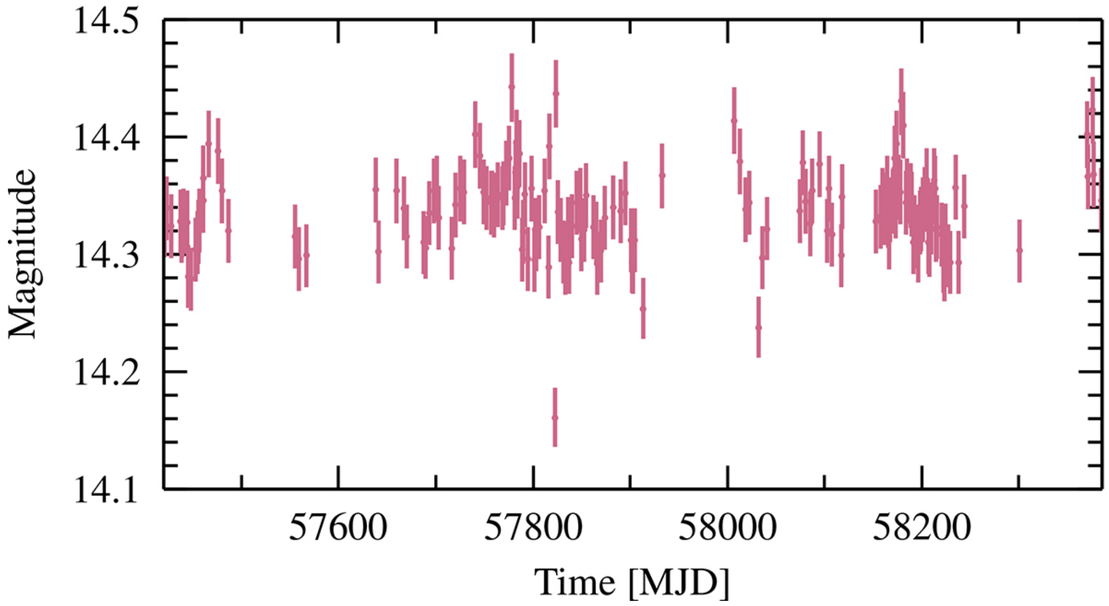
➡ Emission lines similar to those found in Mira variables — which are extremely variable cool giants.

Caption

Zainab+25

So, *is* the donor a Mira variable? No, just a dramatic red supergiant!





- Emission lines similar to those found in Mira variables — which are extremely variable cool giants.

Caption

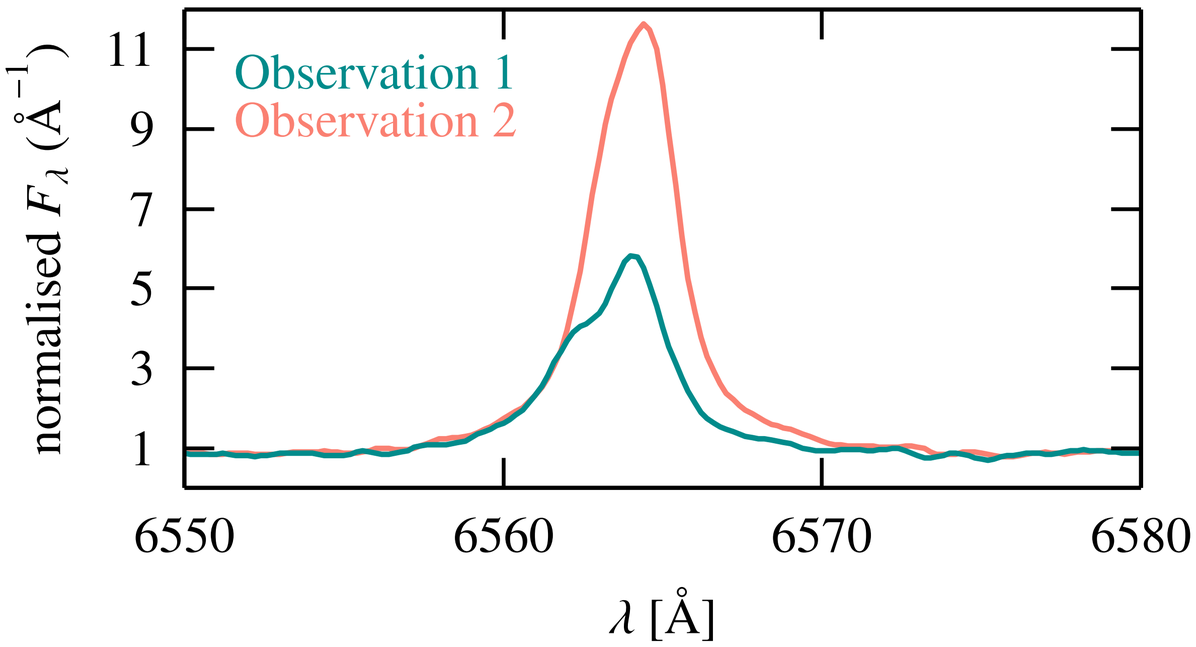
- Variability inconsistent with the Mira scenario, but there *is* some variability.

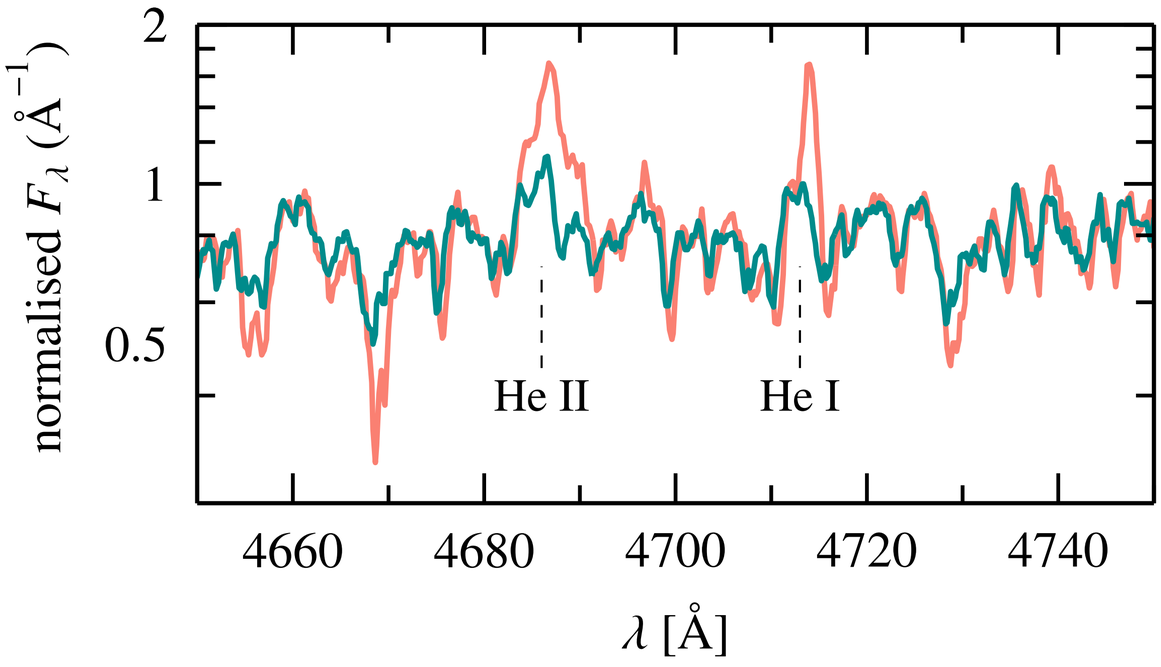
Caption

- Other indicators (e.g., EW[CO(2,0)]) suggest supergiant scenario. (De+24, Zainab+25)

Zainab+25

The big and small questions





- Where is the material causing these emission lines? *And* allowing persistent accretion!
- A variable red supergiant is likely to be ejecting matter — is there circumstellar material that is ionised by the (possibly slowly spinning) neutron star?
- Is the absorbing medium in X-rays the same as the source of optical emission lines?

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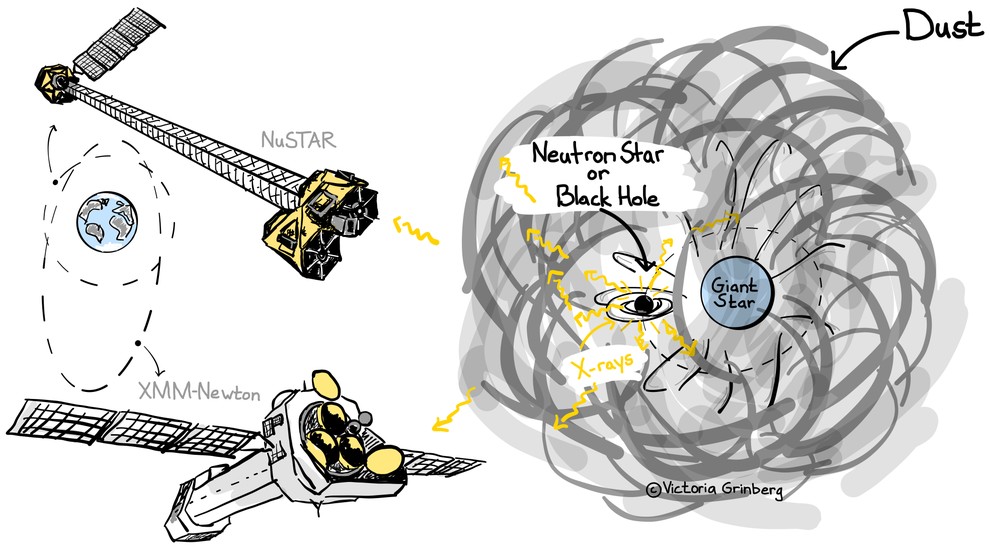
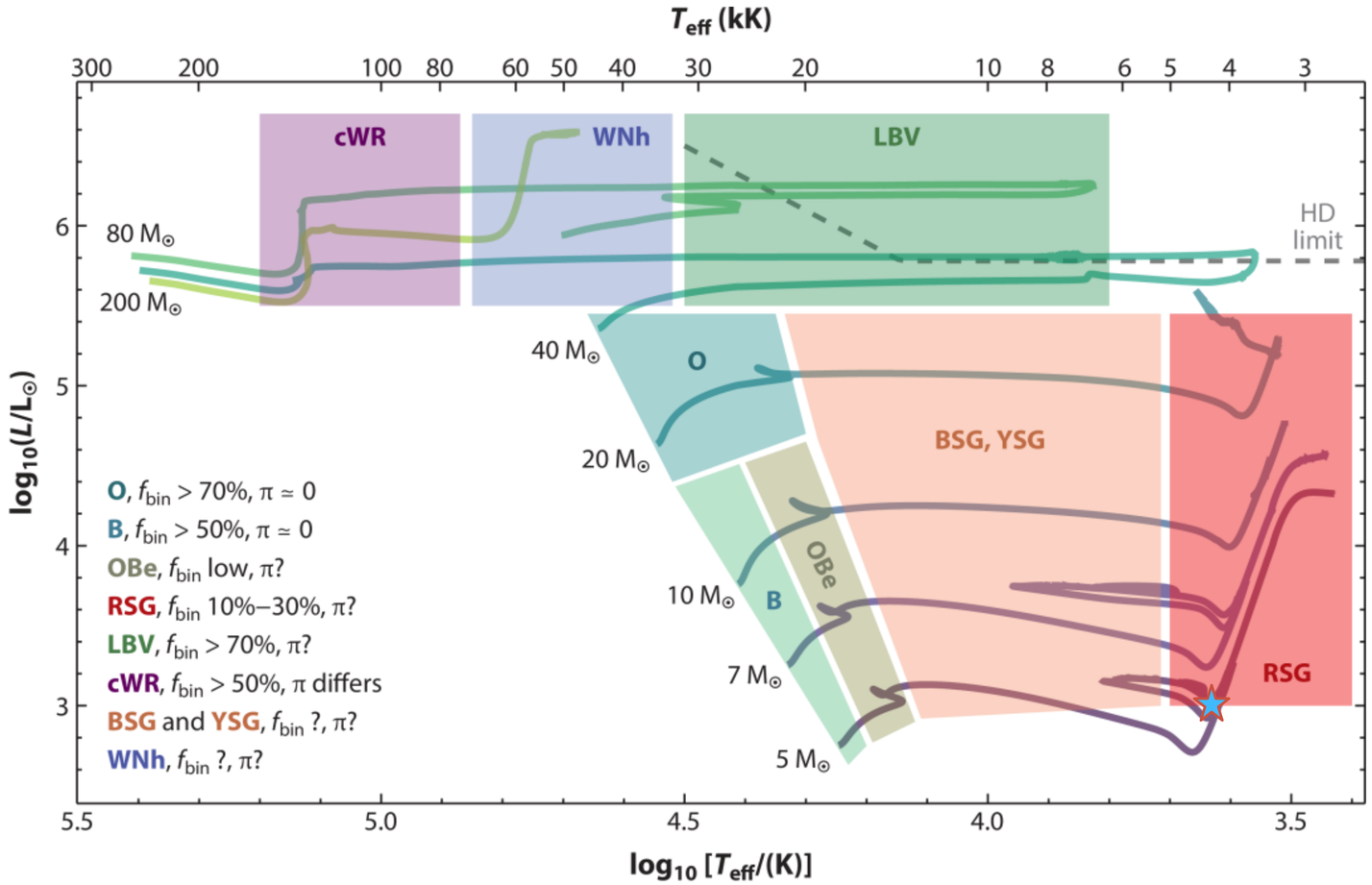
Is dust to be blamed?





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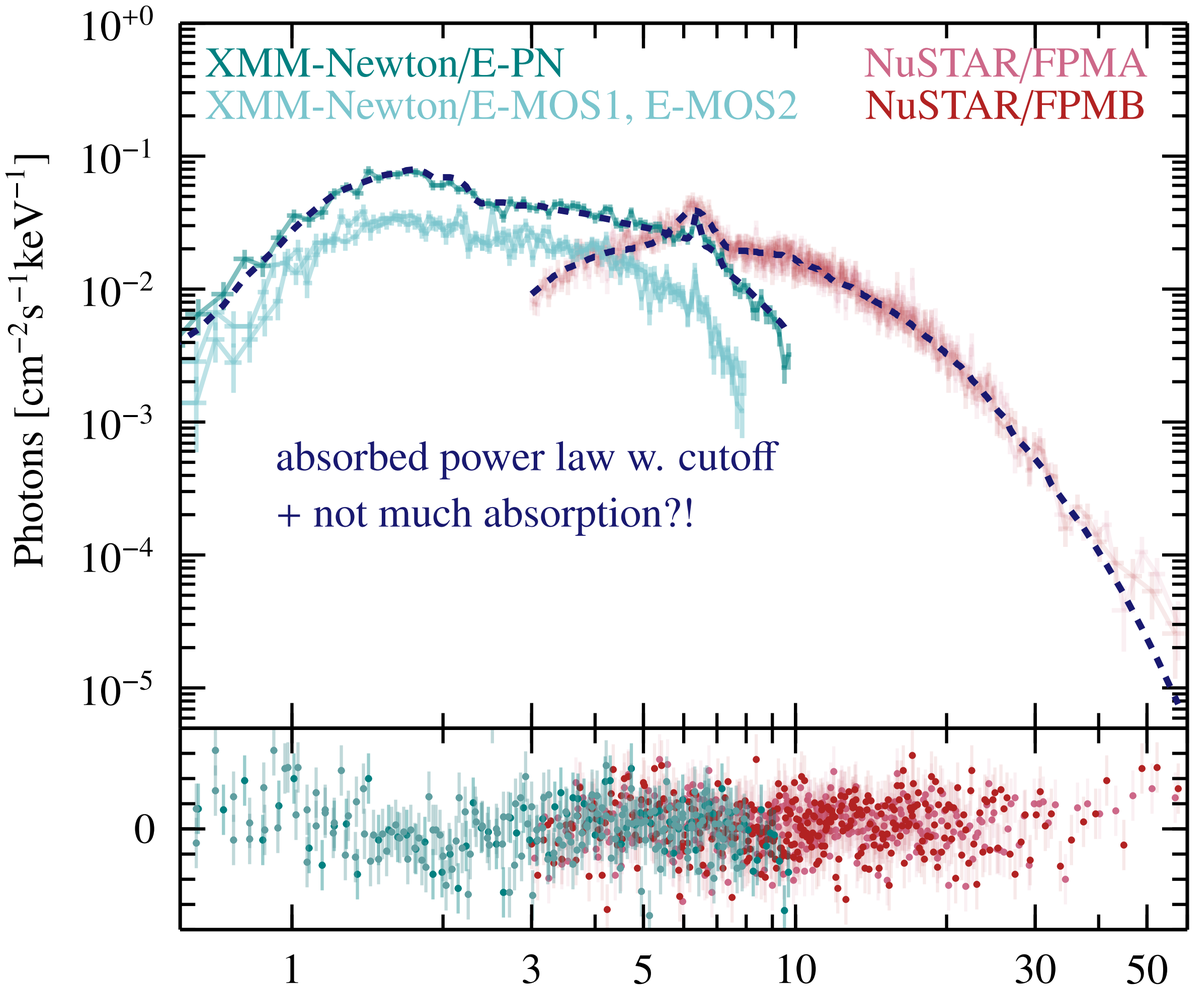
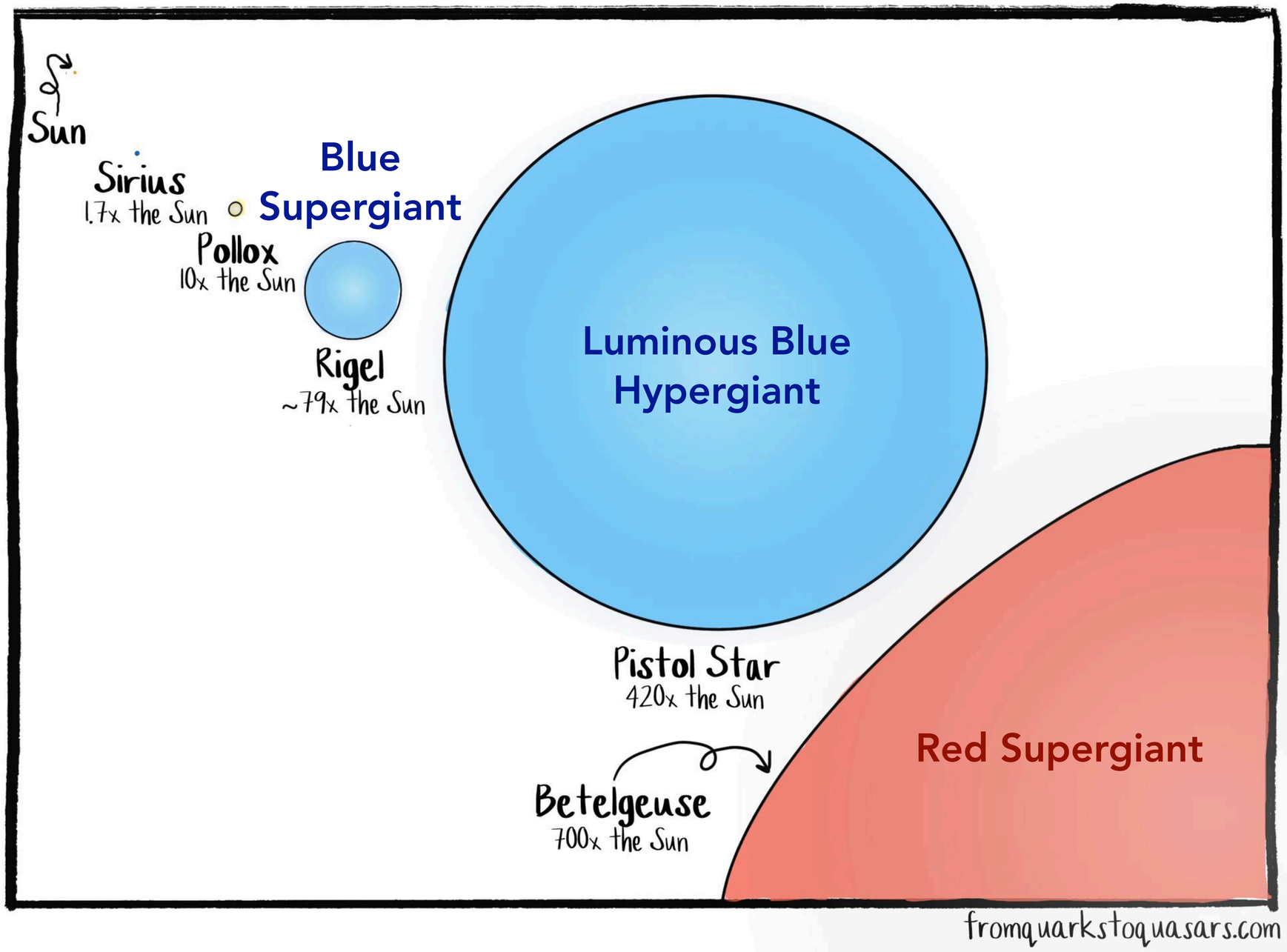
Annu. Rev. Astron. Astrophys. 62:21–61

And lo, and behold, more questions than answers



- More than 30% of the observation affected by a solar flare
- Not as much obscuration in recent XMM spectrum.
- The flux is remarkably stable, despite the difference in iron line flux.
- Still no pulsations…
- Variable obscuration — orbital dependence?
- Radial velocity measurement scarce, but important.

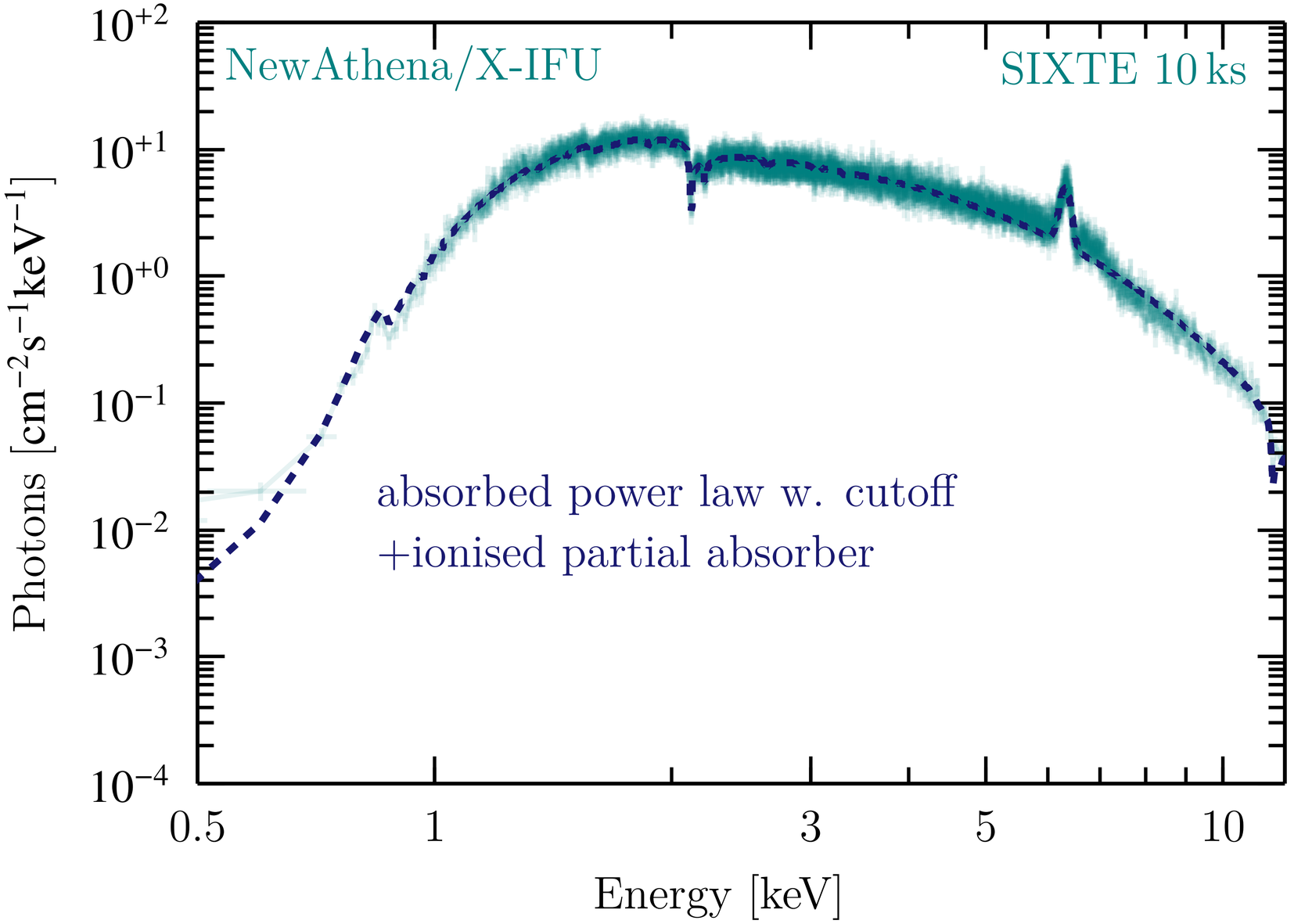
Zainab in prep.



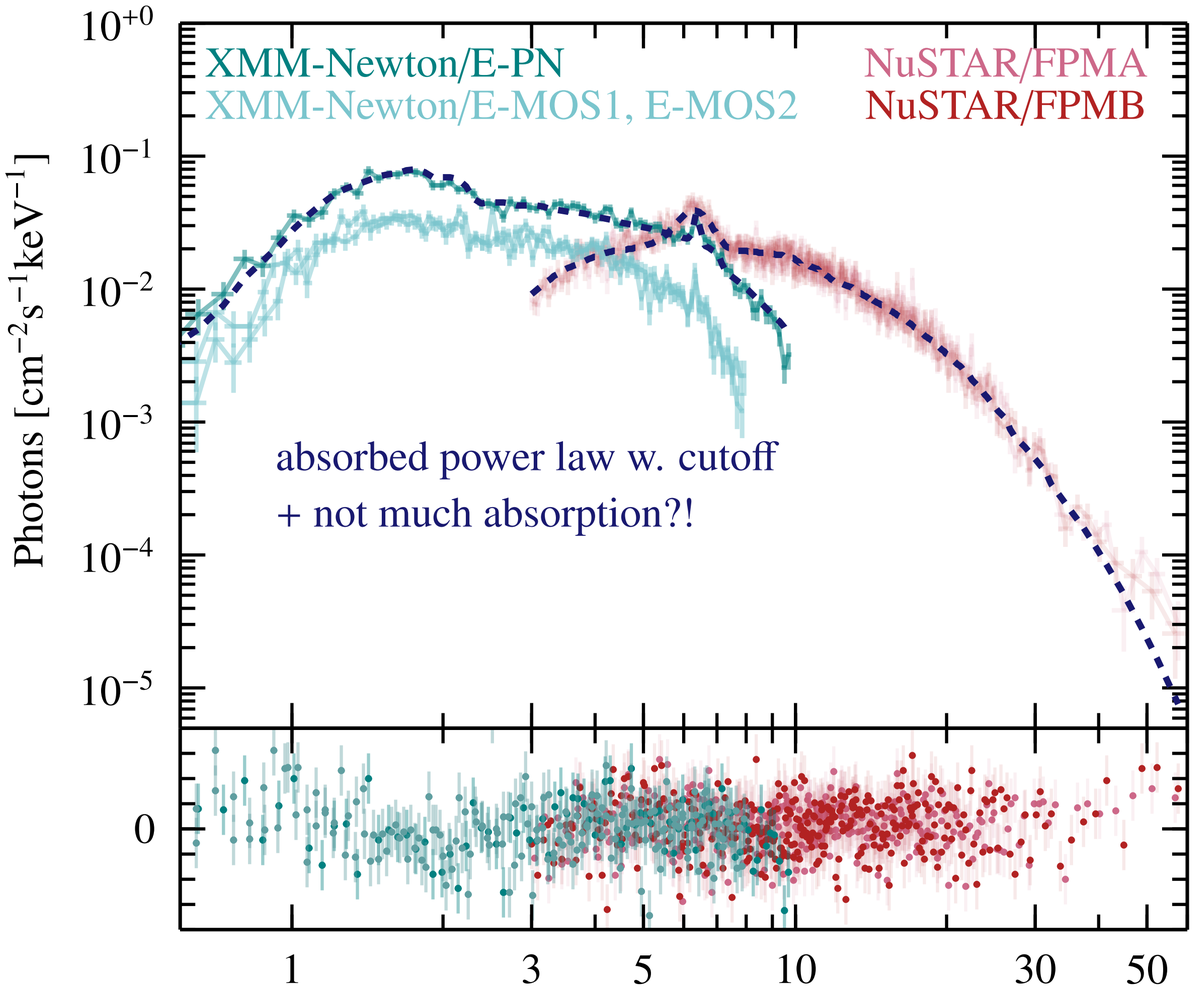
- Orbital parameters are tricky to determine.
- Persistent low mass accretion gives a $< 2000\,R_{\odot}$.
- 4U 1954 (the other RSG-XB in the Milky Way) has an orbit >3 years.

Looking to the future to map the lives of massive stars

- X-ray binaries with RSGs are incredibly rare (even more so, if hosting a black hole), and are probes of star formation history of galaxies.
- NewAthena's capabilities will allow to study the circumstellar medium of these rare systems like never before.



Current conundrums and a conclusion

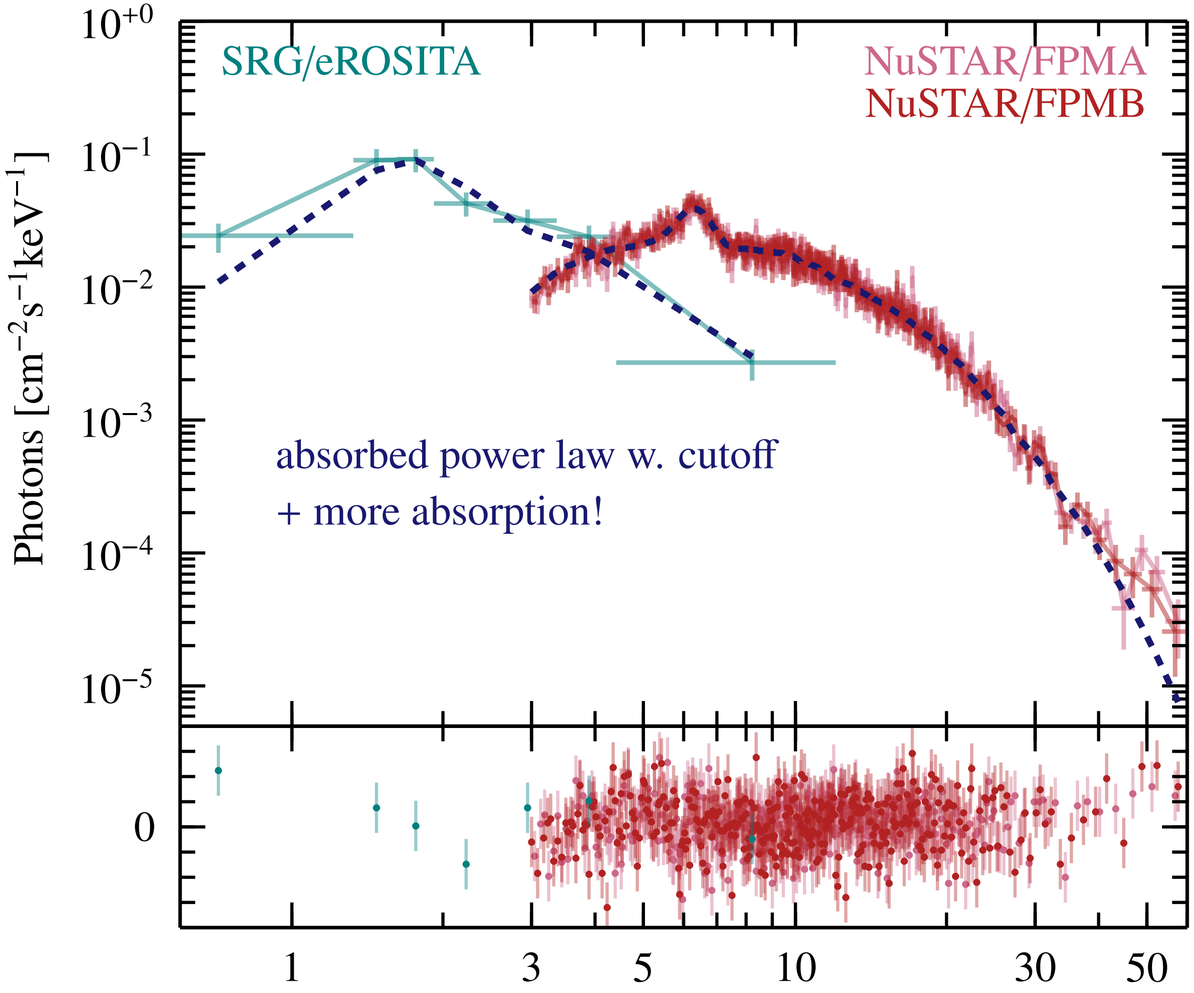


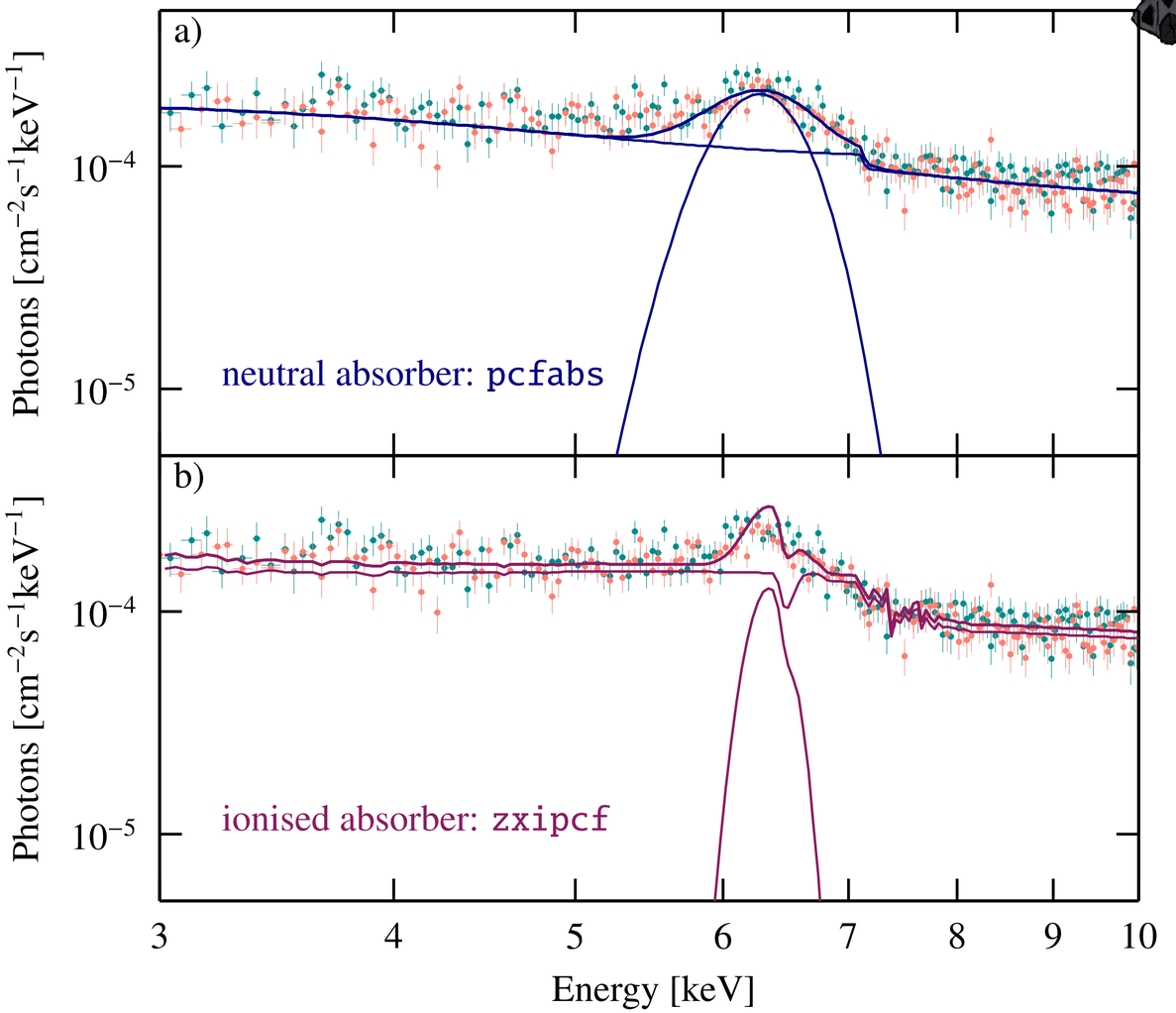
Summary:

- A rare HMXB with a red supergiant.
- Unclear on source of obscuration / optical emission lines.
- Radial velocity study of lines underway.
- Simultaneous multiwavelength data necessary to probe X-ray-optical correlation.
- Is the RSG in the pre-supernova phase?
- Orbital constraints needed!

Zainab in prep.

An ionised absorber works equally well for NuSTAR





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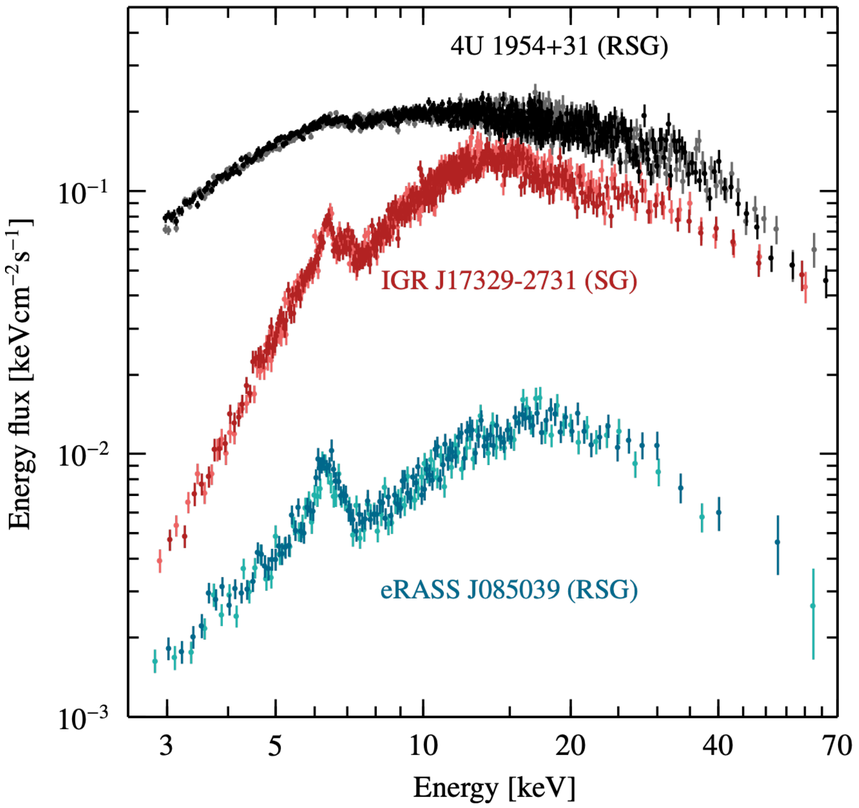
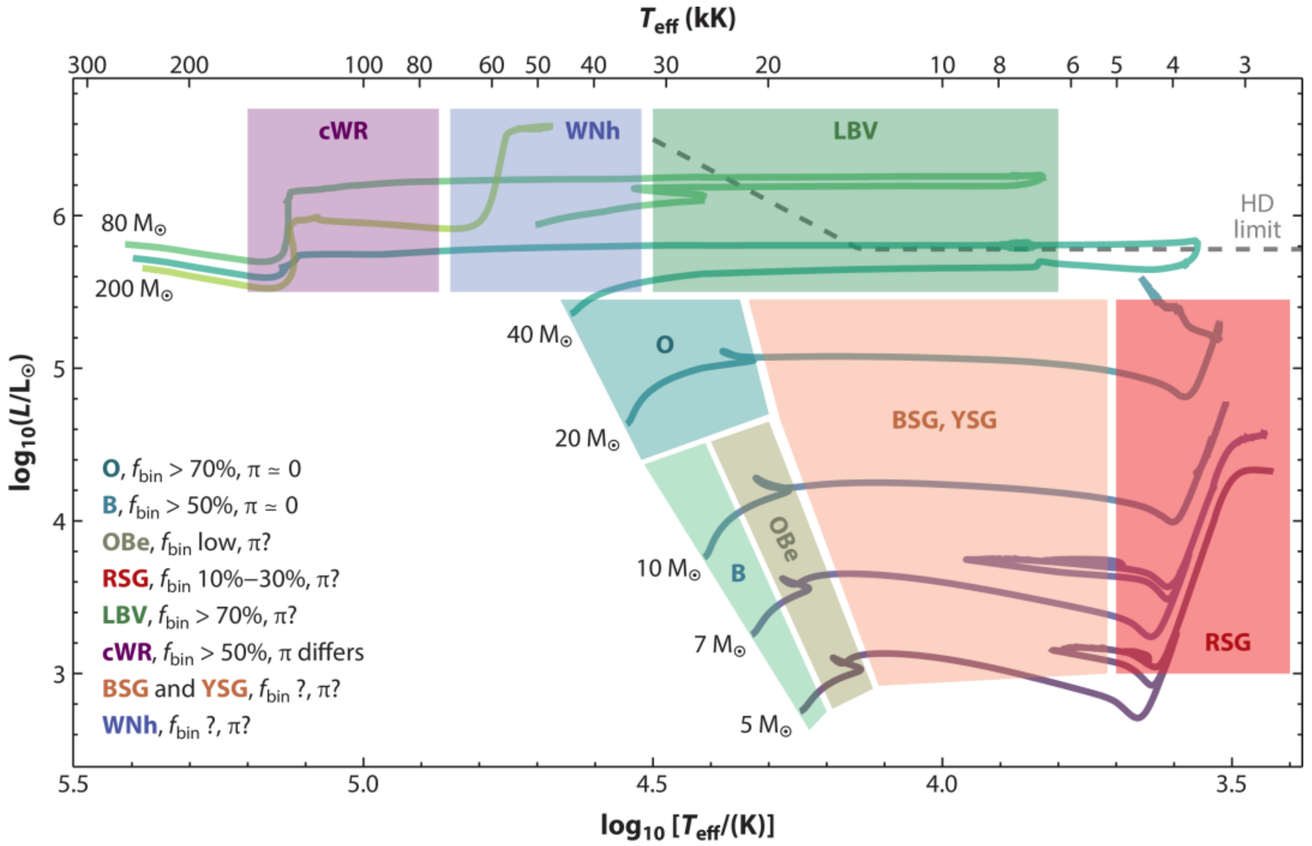
Where is the obscuration coming from?



Caption



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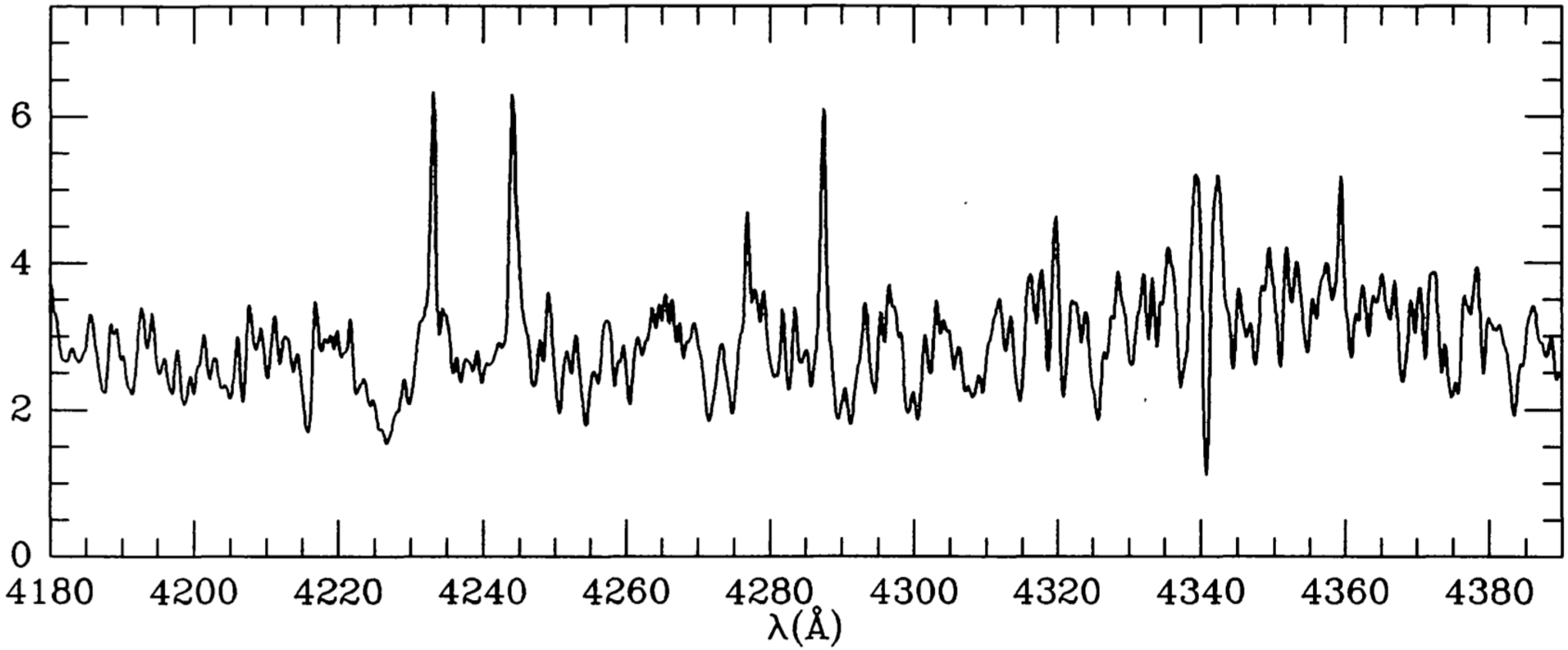
- The high obscuration and the variable emission lines due to circumstellar dust?
- Such X-ray signatures are seen in obscured sgB[e]XBs — could there be an evolutionary link?

Zainab+25

Other (out there) scenarios!



Optical spectrum of VV Cep taken from Altamore+92.

- VV Cep is an RSG+Be binary, with similar emission lines — could we be seeing a triple system?

Zainab+25