The ULX M81 X-6: clues for a precessing disc around a weakly magnetised NS

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(Amato et al., 2022, A&A, accept.)

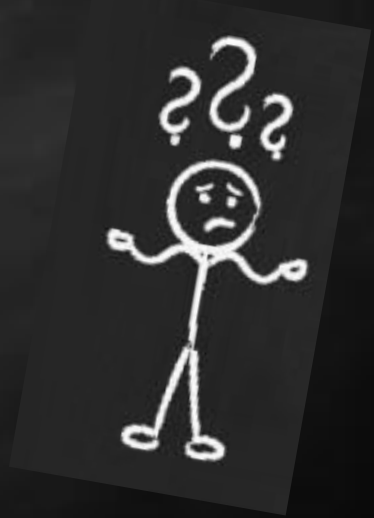
CONGRESSO NAZIONALE OGGETTI COMPATTI XII

27-30 September 2022, Cefalù, Italy

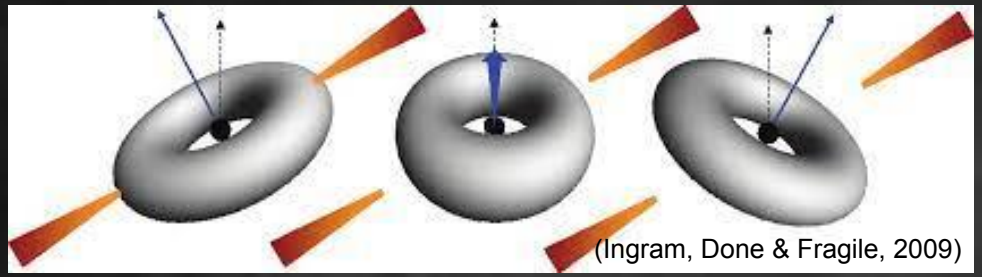
How can we determine the nature of the compact object in ULXs when pulsation is not detected?

Why is it important?

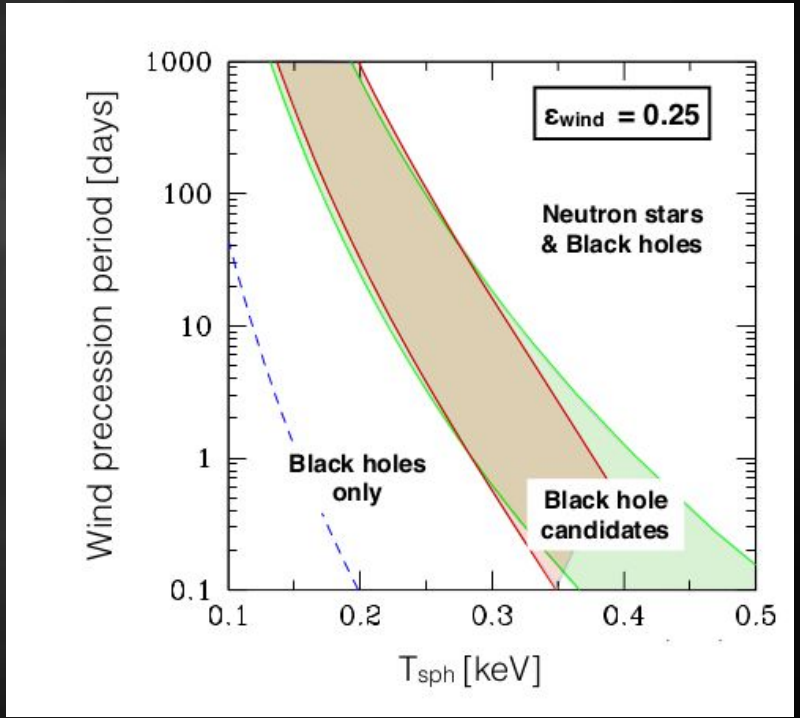
- BH-/NS-ULX population ratio
- Spectral and temporal characteristics
- Binary evolution



1. Lense-Thirring precession in ULXs (Middleton et al., 2018, 2019)

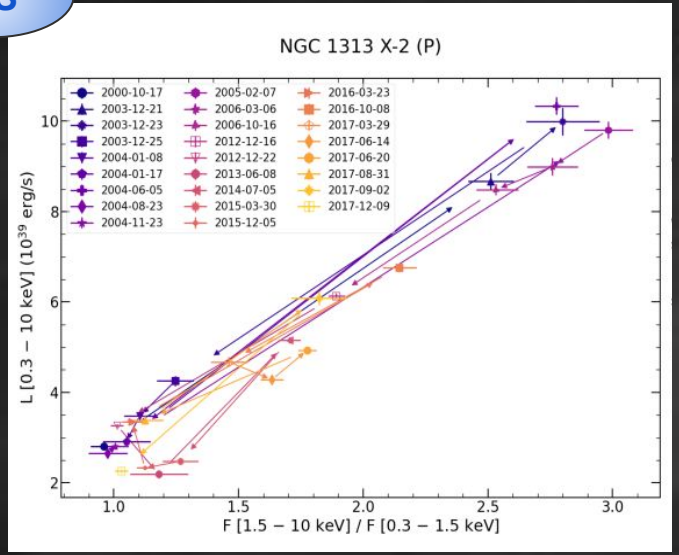

(Ingram, Done & Fragile, 2009)

➔ BH and NS occupy different areas on the LT plane

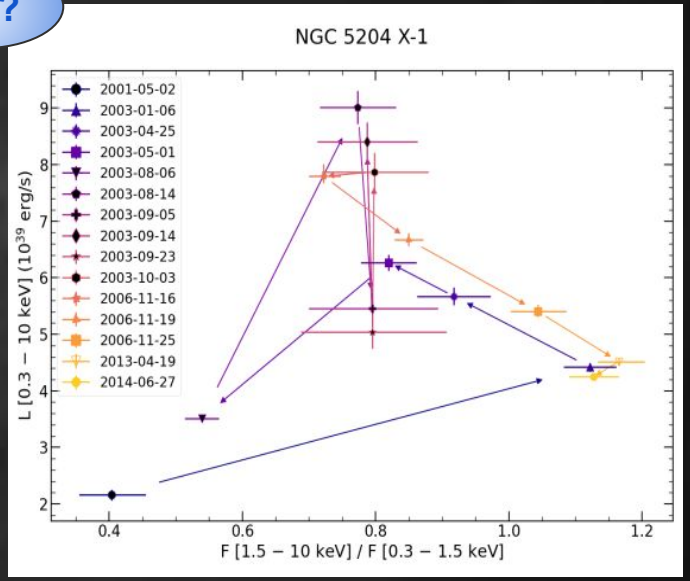


2. Long-term X-ray spectral evolution of ULXs (Gúrpide et al., 2021a,b)

NS



BH?



➔ The temporal track on the HIDs is different for BH-/NS-ULXs (?)

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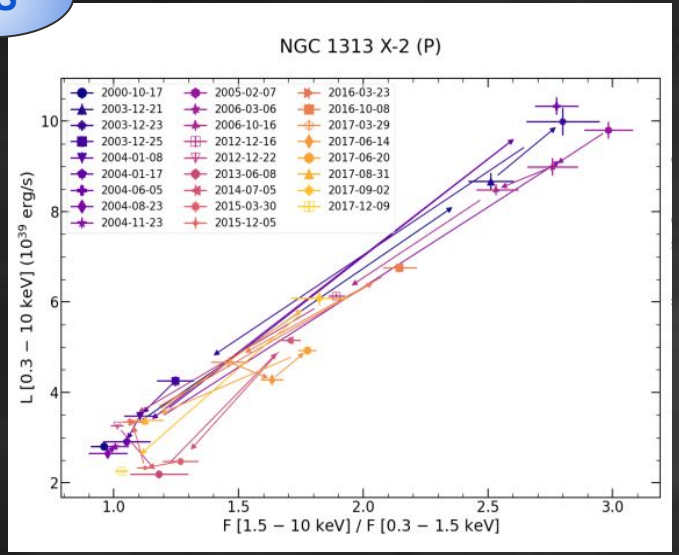
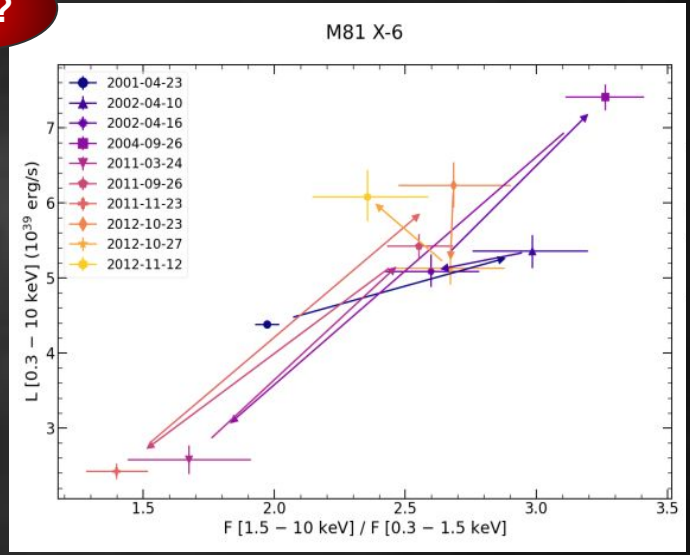
NS



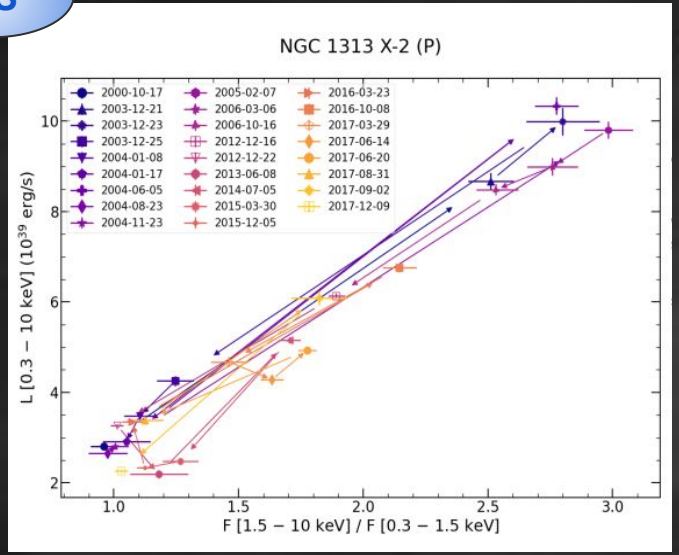
NS?



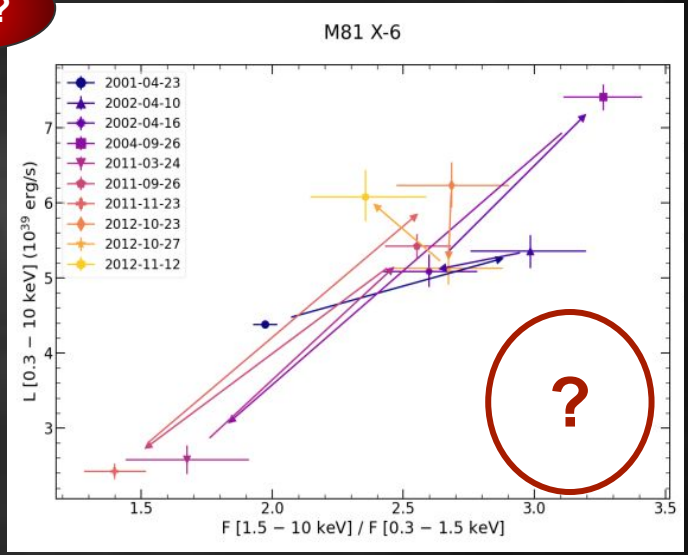
➔ M81 X-6 as a NS-ULX candidate

2. Long-term X-ray spectral evolution of ULXs (Gúrpide et al., 2021a,b)

NS



NS?



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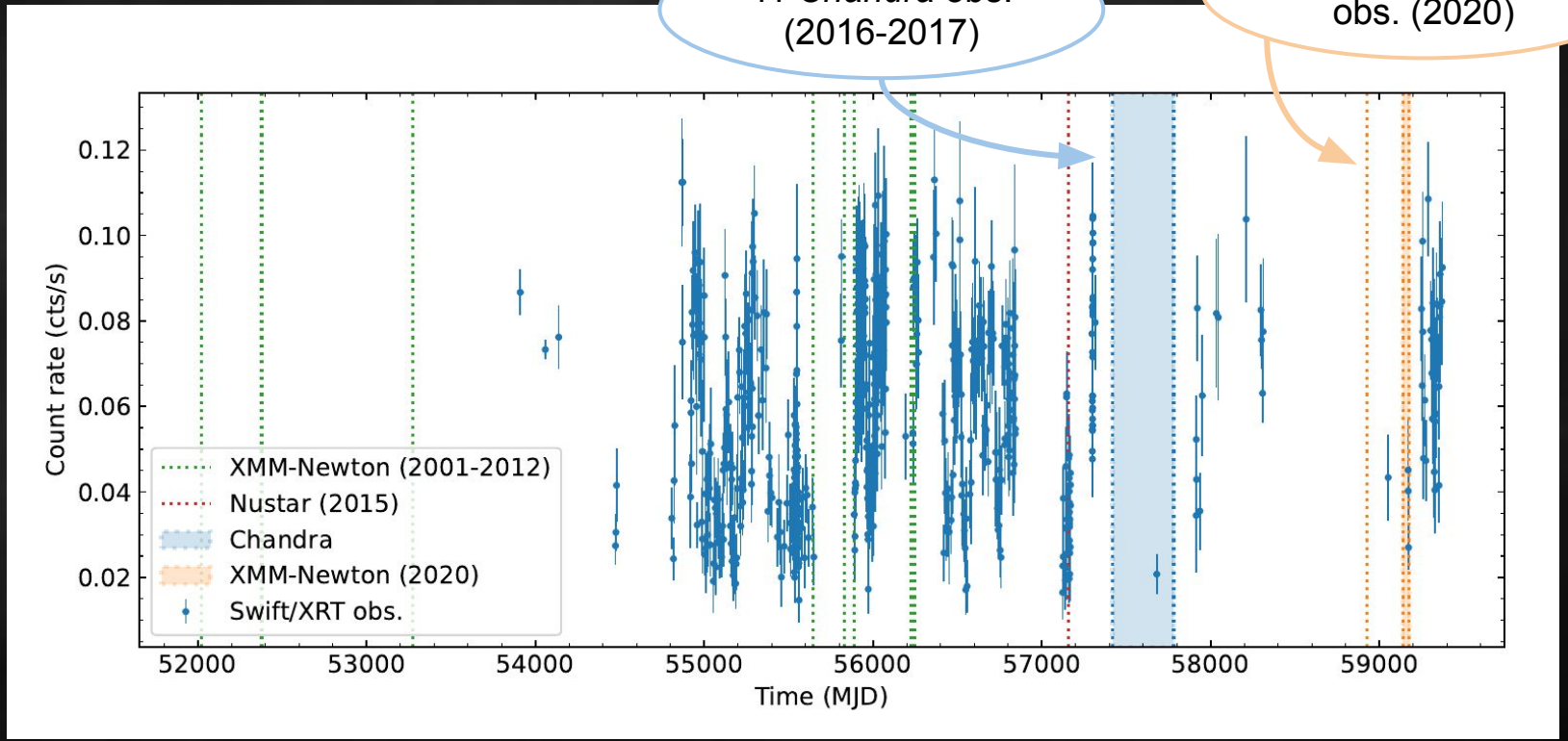
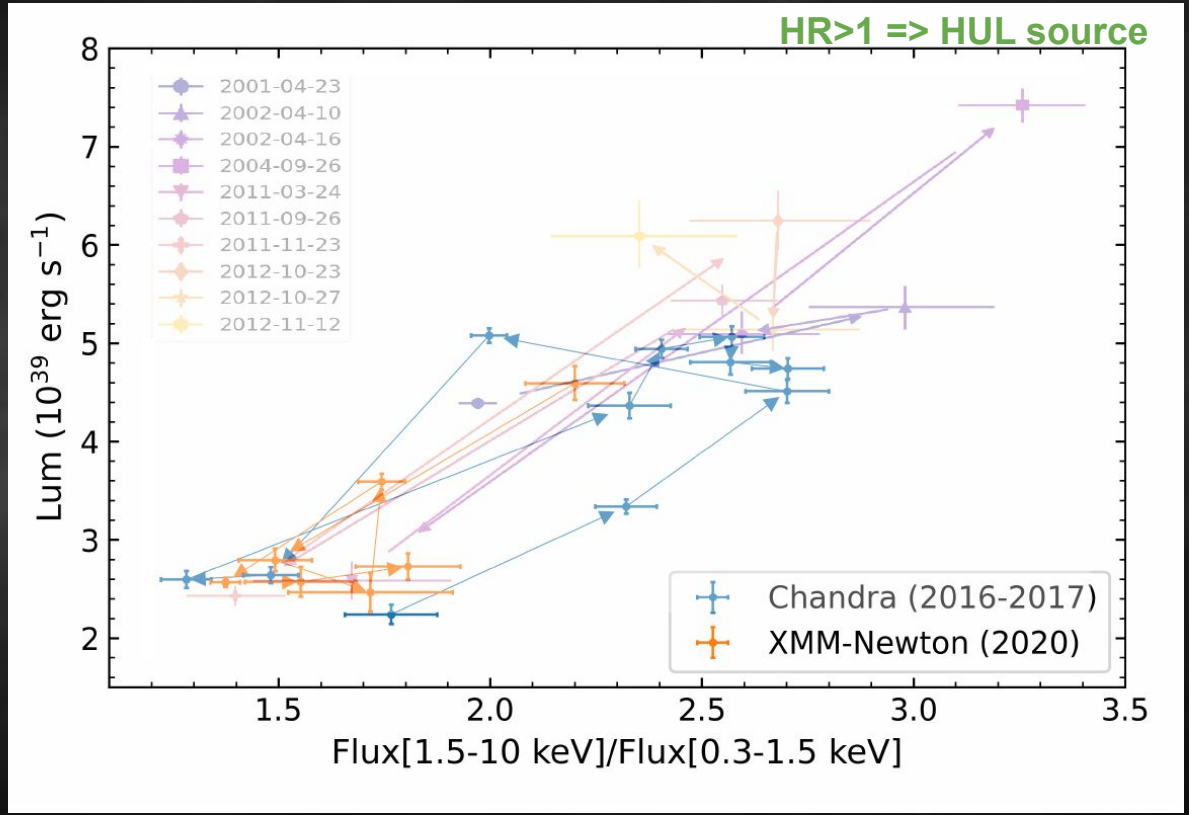
The ULX M81 X-6

Long-term light curve:



The ULX M81 X-6

Hardness-Intensity diagram (HID):



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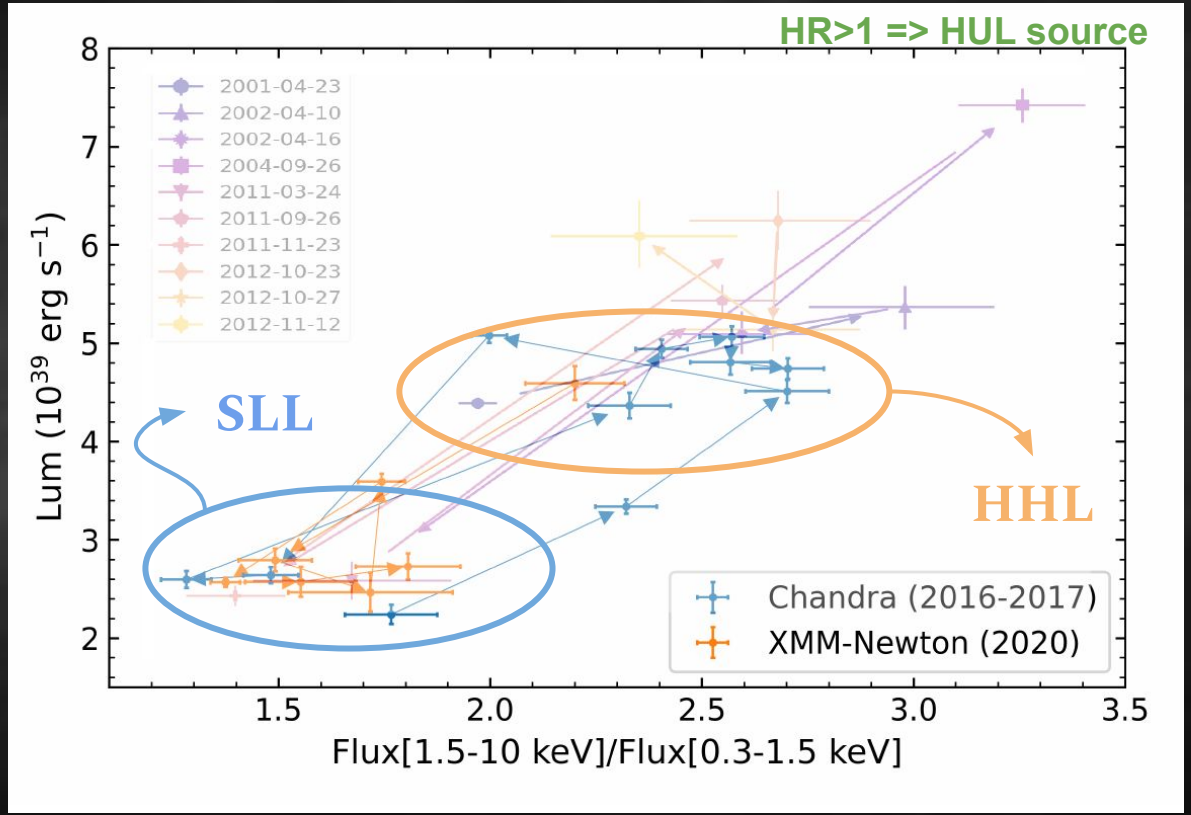

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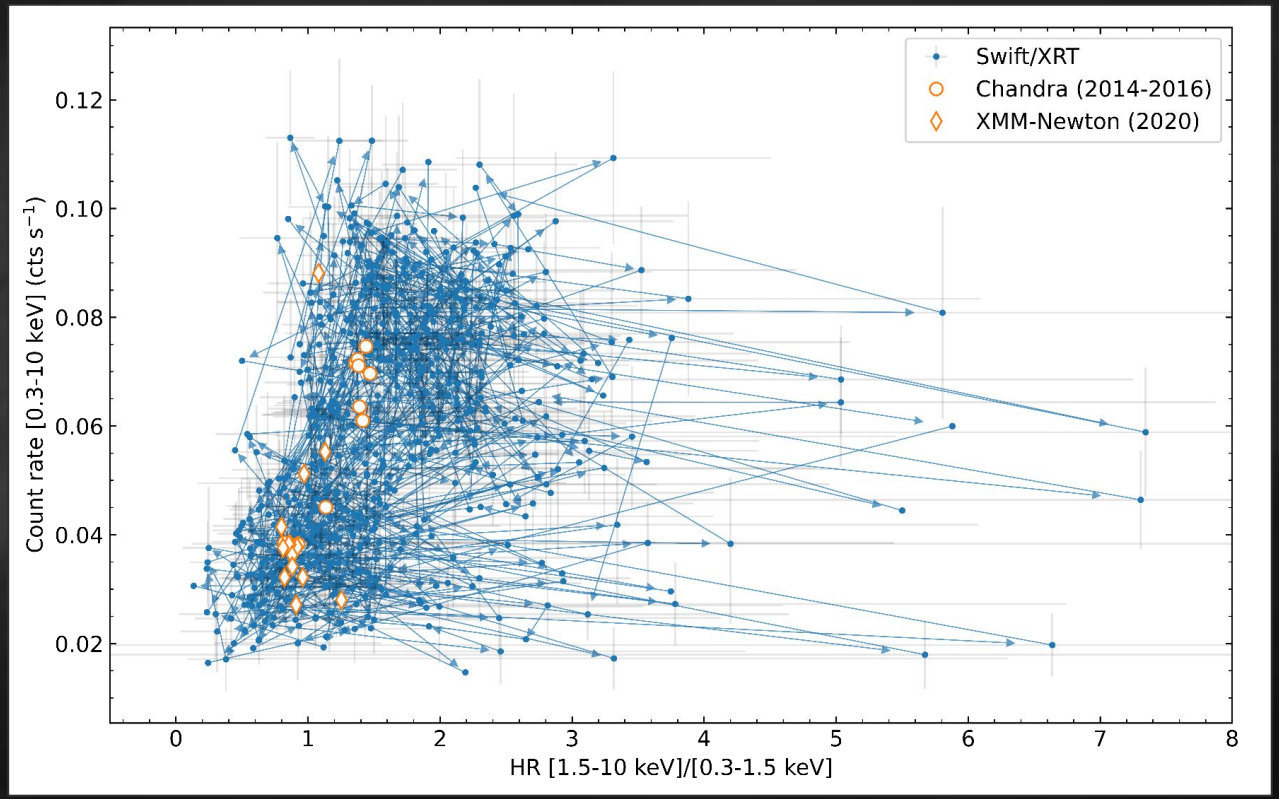

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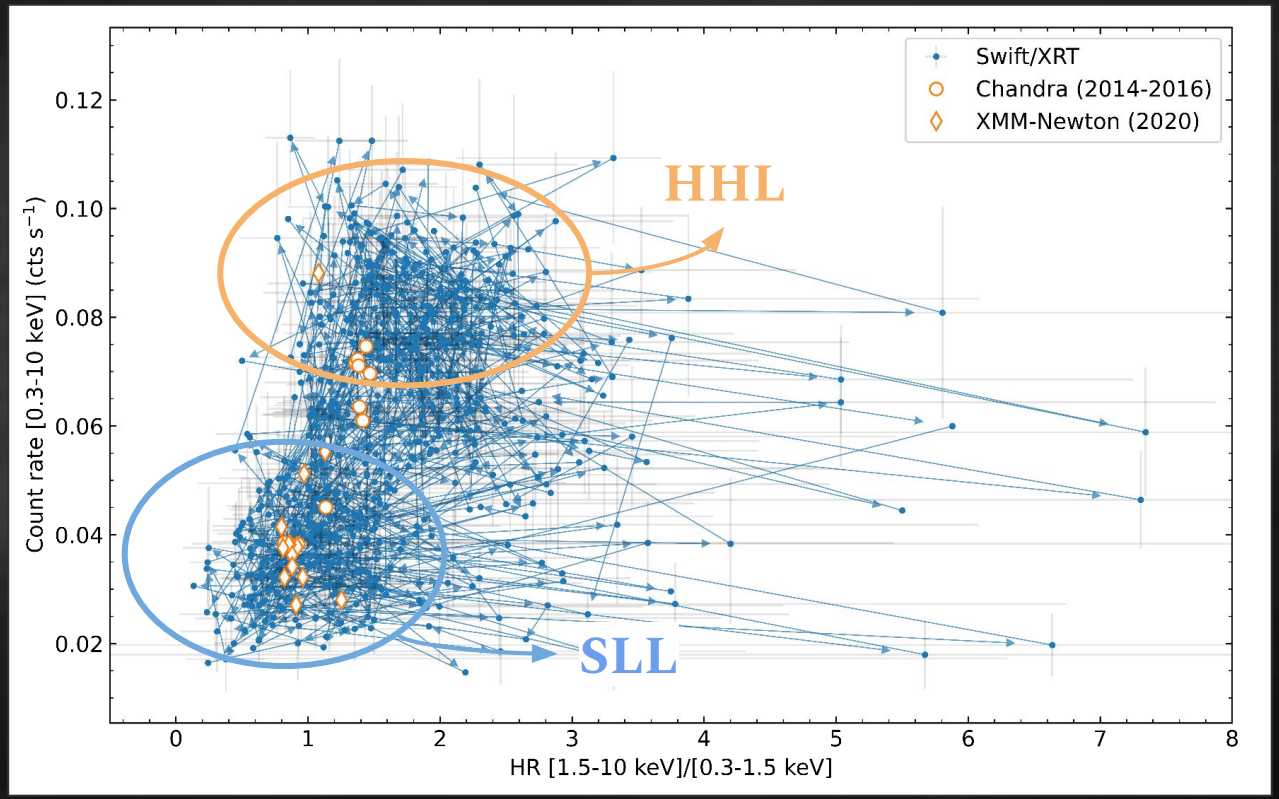
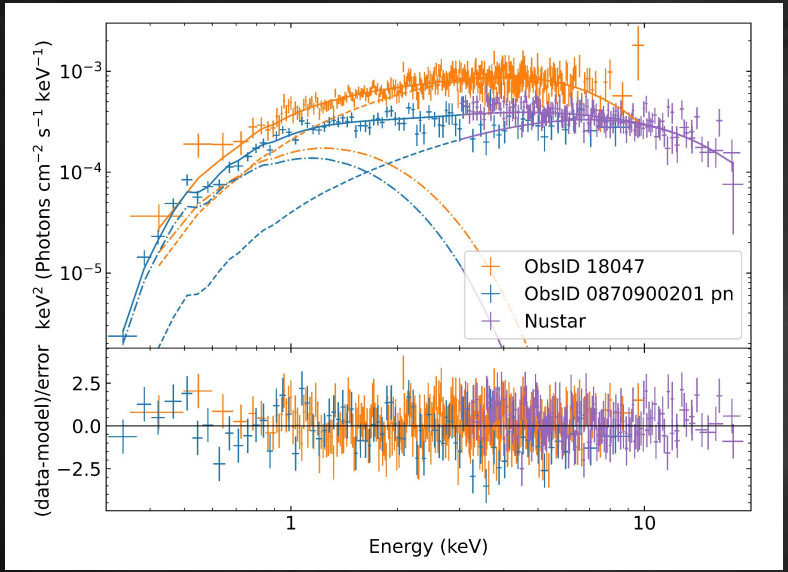


The ULX M81 X-6

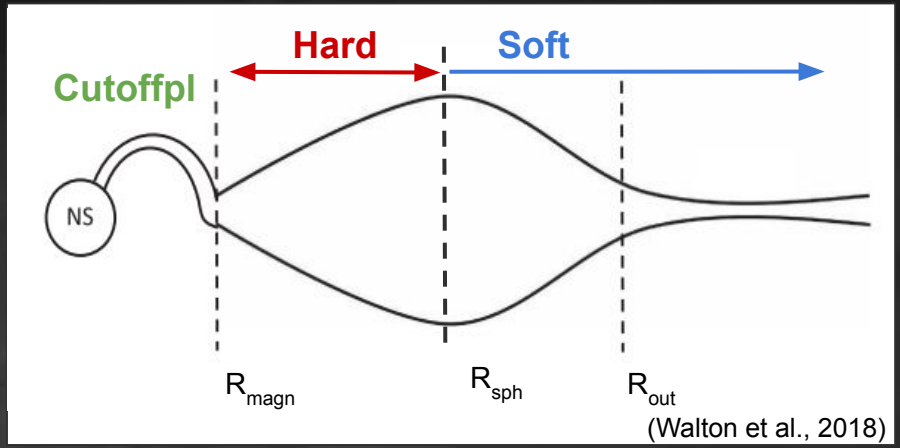
Spectral characterisation:



- **`tbabs*tbabs*(diskbb+diskbb+cutoffpl)`**
- Cutoff power law modeled thanks to *Nustar* data in the SLL state
- Variability in the hard band
- Different T_{hard} (temp. inner disc)
- Same T_{soft} (temp. outer disc)
- F_{cutoff}/F_{tot}=50% SLL

Note: No high-energy data available ⇒ power law likely underestimated in the HHL state.

The ULX M81 X-6



(Walton et al., 2018)

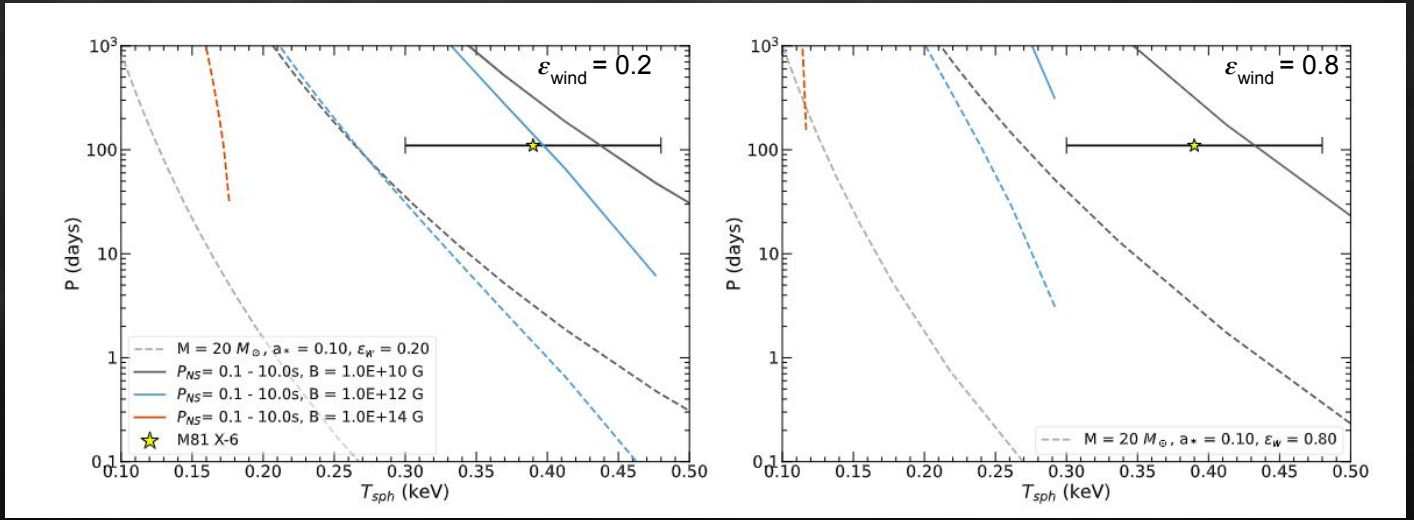
On the origins of the two spectral states:

- T_{soft} corresponds to the temperature at R_{sph}, which is $\propto \dot{m}^{-½}$. It is constant in both states => **Constant accretion mass rate**
- Changes in luminosity not enough for transition to **propeller regime** (assuming same spin period as other ULXs)
- Superorbital period (~110 d) would point to the **precession of the accretion disc**

The ULX M81 X-6

Lense-Thirring precession (Middleton et al., 2018, 2019):

- $B \leq 10^{10}$ G => **low-magnetised NS**
- P_{spin} ~ 5–7 s
- Constraints on R_{magn}, R_{sph}, R_{out}, consistent with values from the best fit
- $R_{magn} < R_{sph}$ confirms diluted pulsation



Conclusions

- M81 X-6 is a HUL source, but exhibits transitions between two regimes: **HHL** and **SLL**
- The two spectral states can be attributed to Lense-Thirring precession
- Favoured scenario: **Low-magnetised NS with spin of a few seconds**
- This method can be applied to NS/BH-ULXs