

# THE CASE OF PULSATING ULX M51 X-7: A QPO TO FIND THEM ALL?

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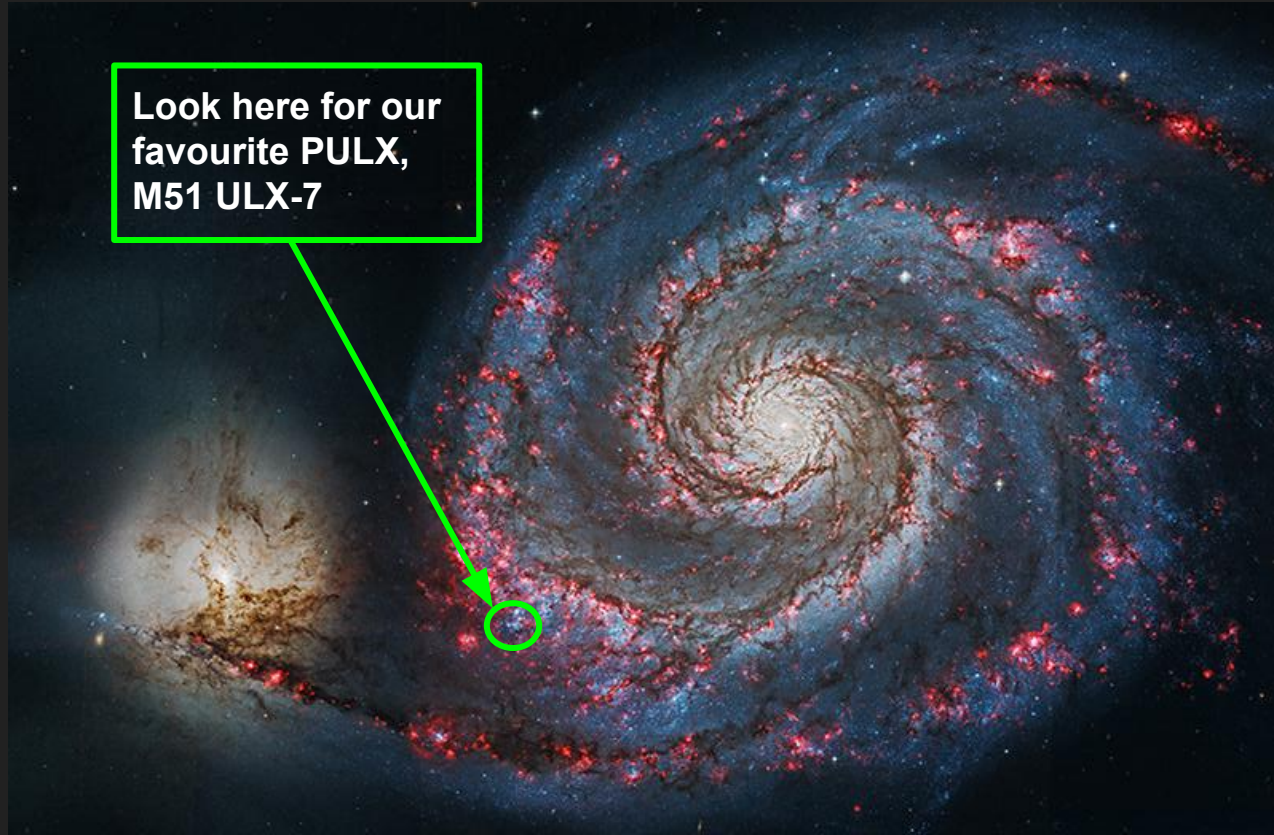


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# M51: THE WHIRLPOOL GALAXY

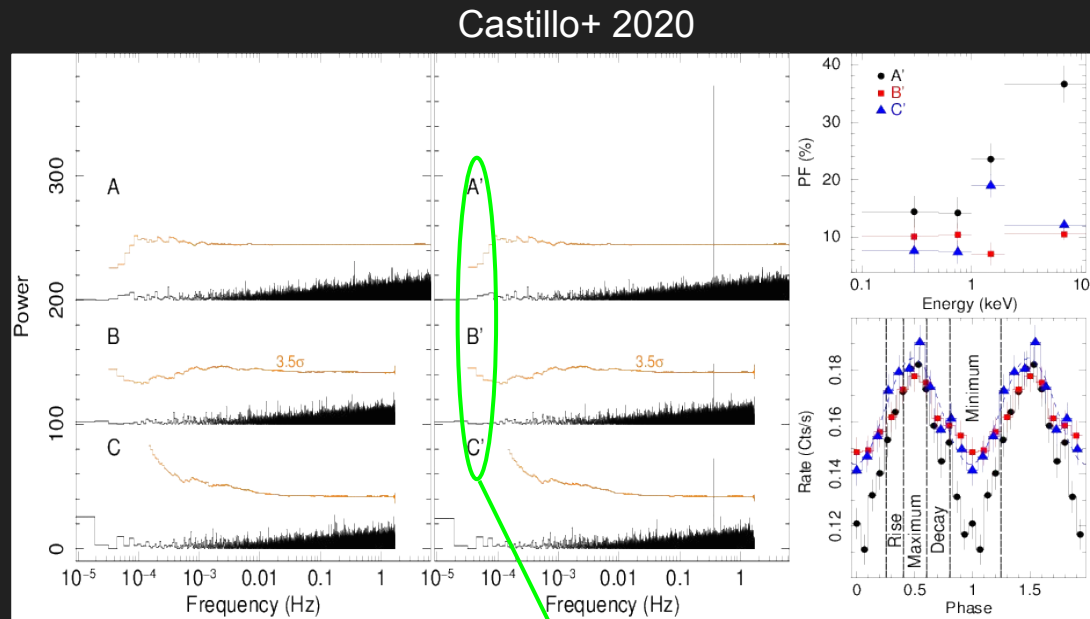
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- Pair of interacting galaxies, hosting 9 ULXs (Terashima & Wilson, 2004).
- $d \approx 8.58$  Mpc.
- At least another NS-powered ULX: M51 ULX-8 (CRSF in the spectrum, no detected pulsation yet).



# M51 ULX-7: THE DISCOVERY OF THE PULSATION

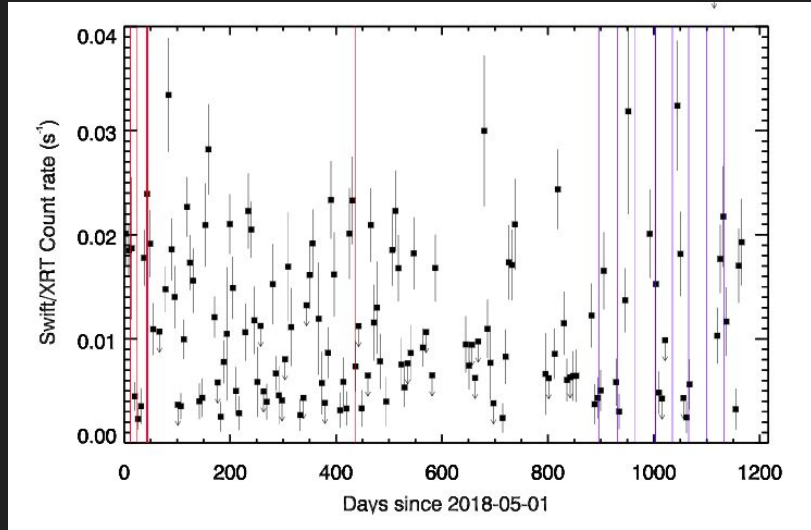
- Signal identified through accelerated search techniques (ask for details!) in 2018 XMM observations.
- Variable PF ( $\sim 5 - 20\%$ ), even within the same obs.
- Source parameters:
  - $P_{\text{spin}} \sim 2.8 \text{ s}$
  - $P_{\text{orb}} \sim 2 \text{ d}$
  - $a_x \sin i \sim 28 \text{ lt-s}$
  - $\dot{P} \sim -1.5 \times 10^{-10} \text{ s s}^{-1}$
  - $\dot{P}_{\text{sec}} \sim -10^{-9} \text{ s s}^{-1}$



PSDs after the  $\dot{P}$  and orbital Doppler correction.

# ULX-7 PROPERTIES

Brightman+ 2022

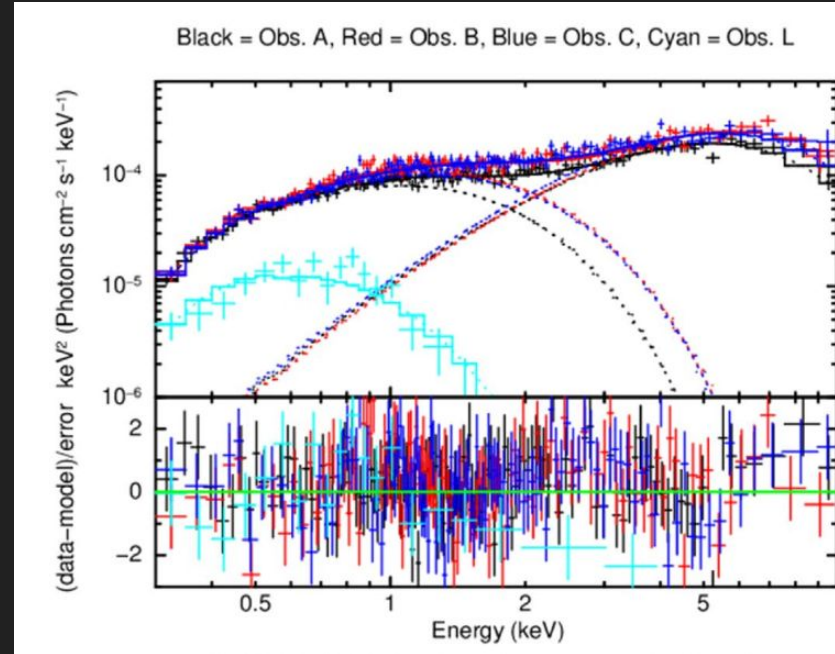


Persistent source (detected in 13 out of 14 XMM observations).

Relatively bright at the peak of the superorbital modulation (see next slide):

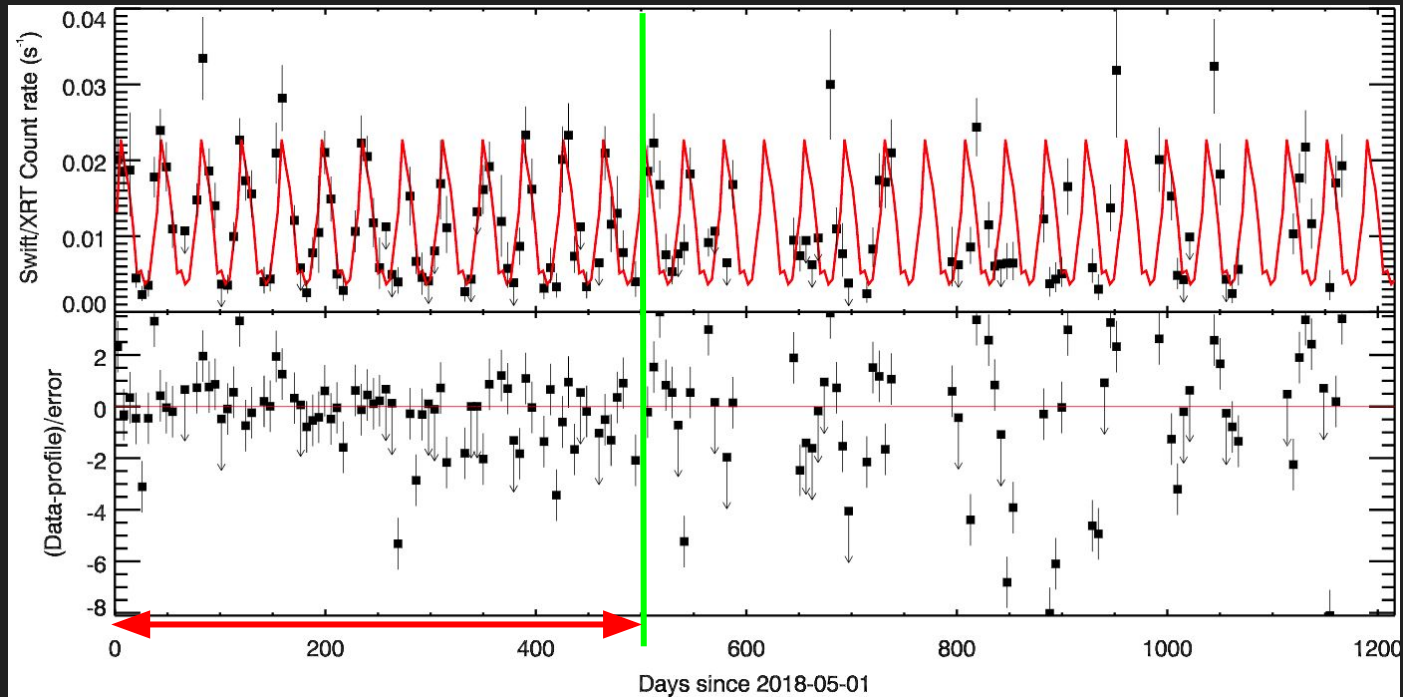
$$F_X \simeq (0.5-1) \times 10^{-12} \text{ erg s}^{-1} \text{ cm}^{-2}$$
$$L_X \simeq (5-7) \times 10^{39} \text{ erg s}^{-1}$$

Castillo+ 2020 (similar spectrum in Brightman+ 2022). Pulsation detected when the hard component is visible.





# THE SUPERORBITAL MODULATION

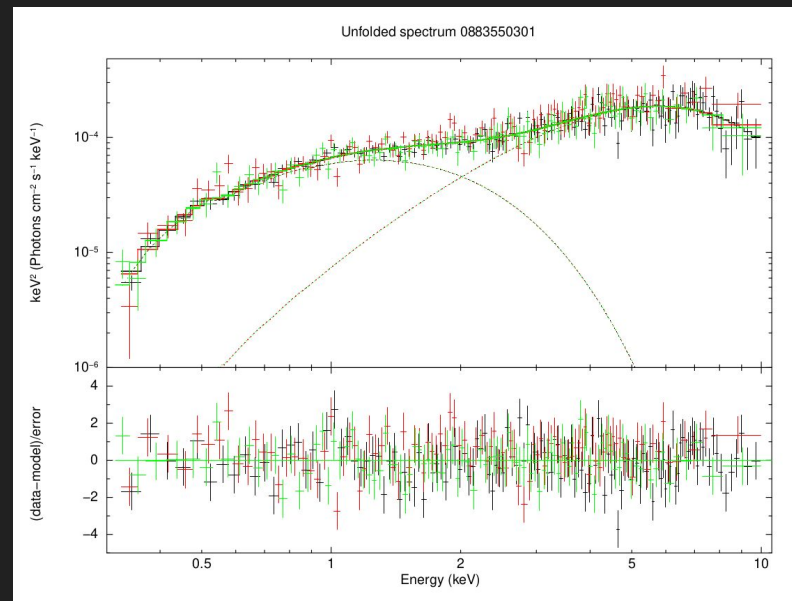
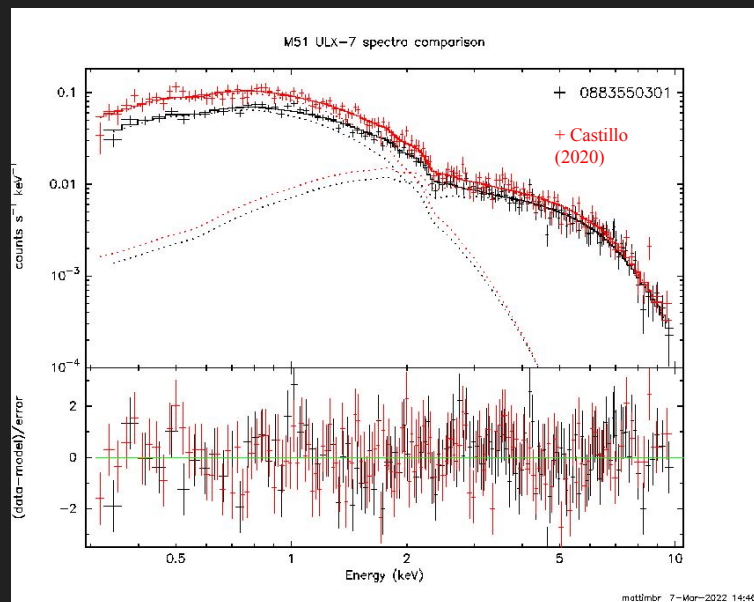


First observed by Brightman+ 2020 ( $P \simeq 38$  d), signs of evolution towards  $P \simeq 44$  d (Brightman+ 2022) after 500 days since the beginning of the monitoring.

Evolution of the period consistent with the hypothesis of the modulation arising from a precessing disk (next talk).

# ULX7: XMM LP OBSERVATIONS

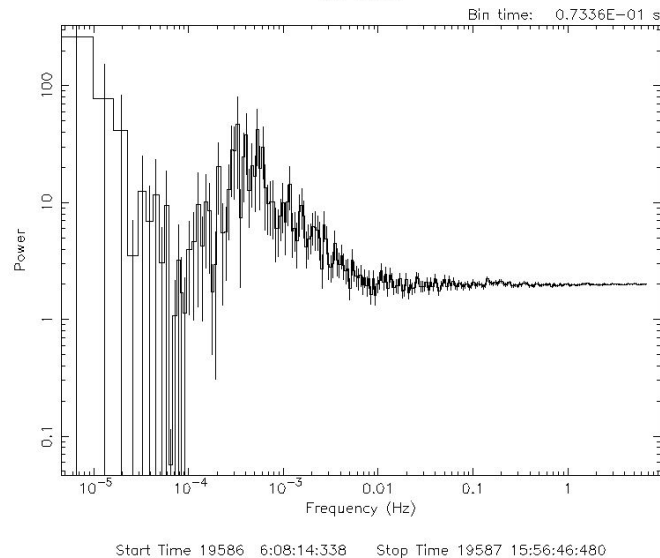
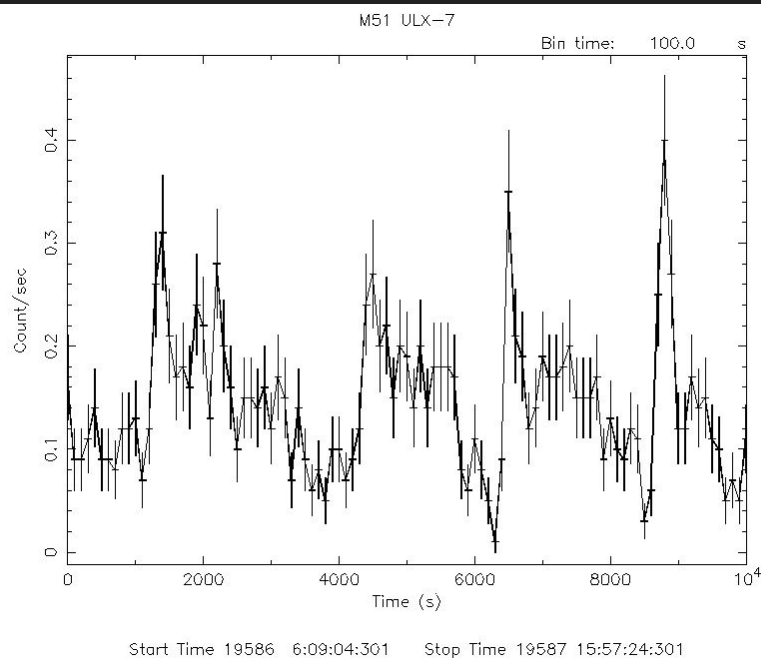
- 3 obs in December/January at the peak of the superorbital modulation: no spin signal found with our accelerated search codes (up to now).



- Apparently favourable spectral state

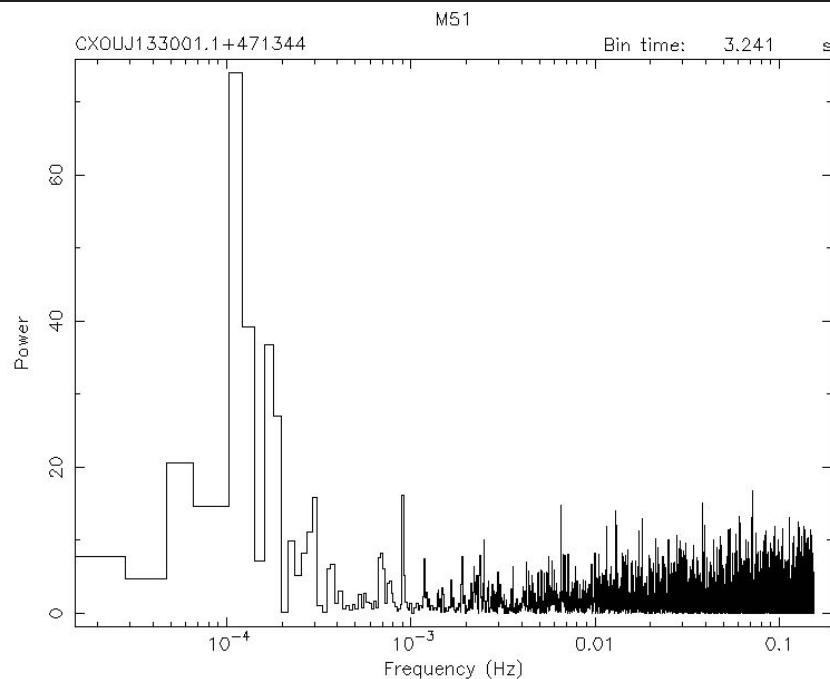
# ULX7: THE SEARCH FOR...A QPO?

- No coherent signal at 2.8 s, but we see a  $\sim 2$  ks periodical modulation.

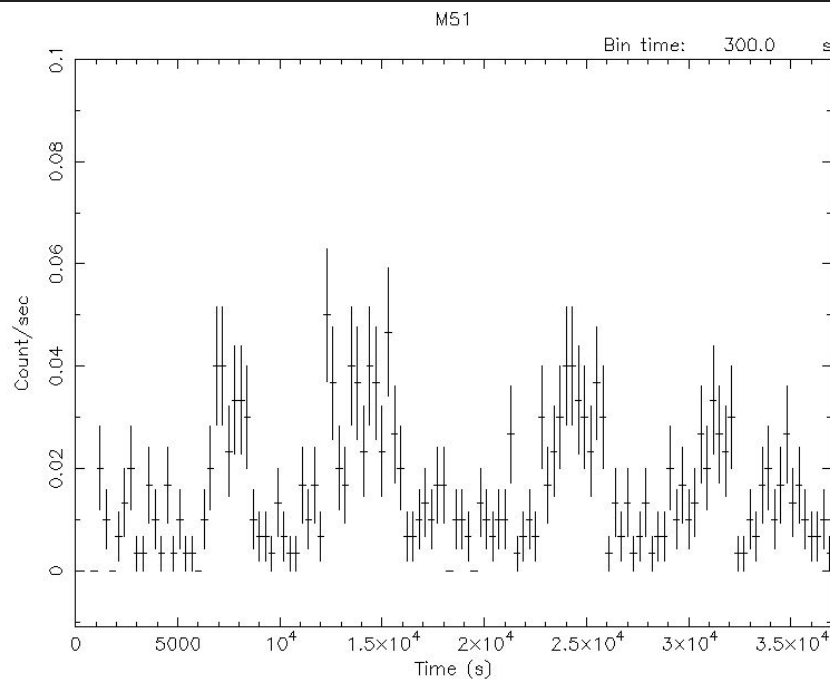


- Absence of signal linked to the presence of this feature?
- Absent in 2018 observations, but what about other observations in the archives?

Total occurrence: 2 out of 20 observations, 11 with XMM, 9 with Chandra



Start Time 19204 8:02:23:876 Stop Time 19204 18:12:31:422

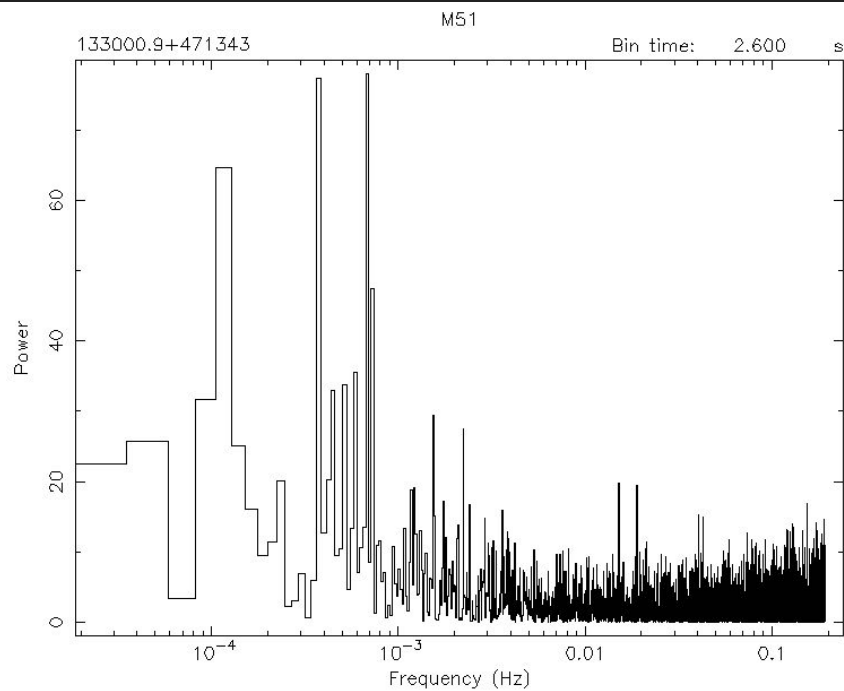


Start Time 19204 7:59:59:552 Stop Time 19204 18:14:59:552

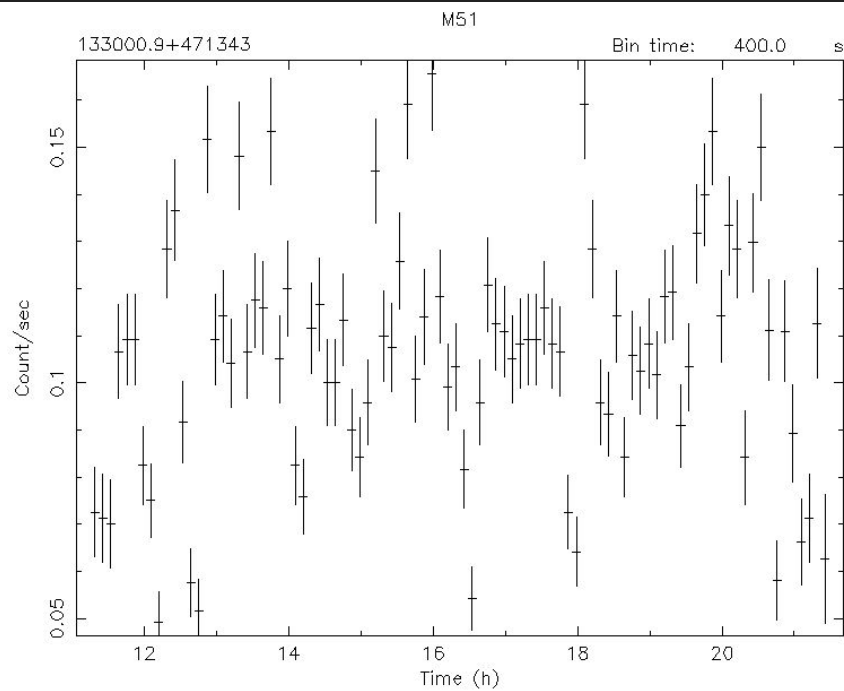
End of 2020, CHANDRA ACIS observation.  
Typical timescale ~ 10 ks: evolution toward shorter timescales?



## XMM Observation (20/5/2006). Less defined shape: different state?

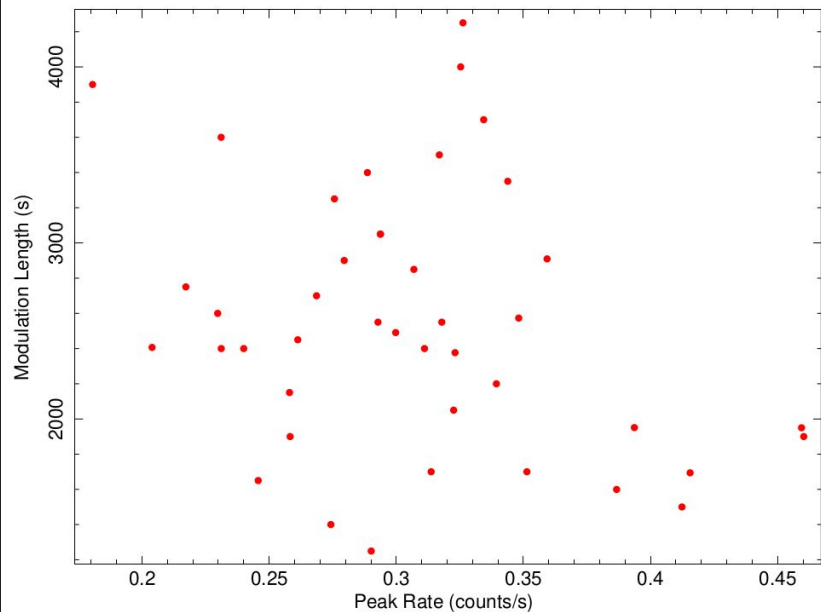


Start Time 13879 11:15:44:842 Stop Time 13879 21:25:13:842



Start Time 13879 11:19:03:542 Stop Time 13879 21:25:43:542

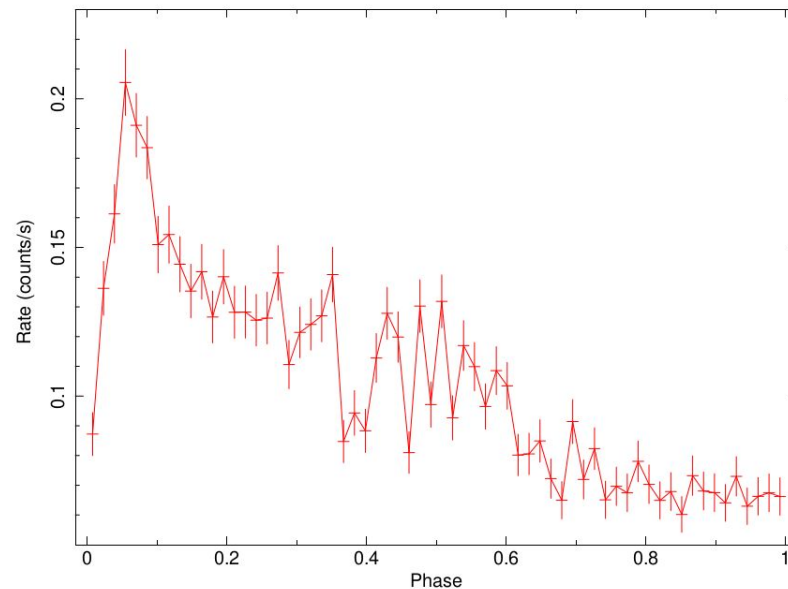
M51 ULX-7 Modulation Length vs Peak



No apparent correlation between modulation length and peak count rate.

Fast rise, rapid initial decay, (plateau?), slower decay.

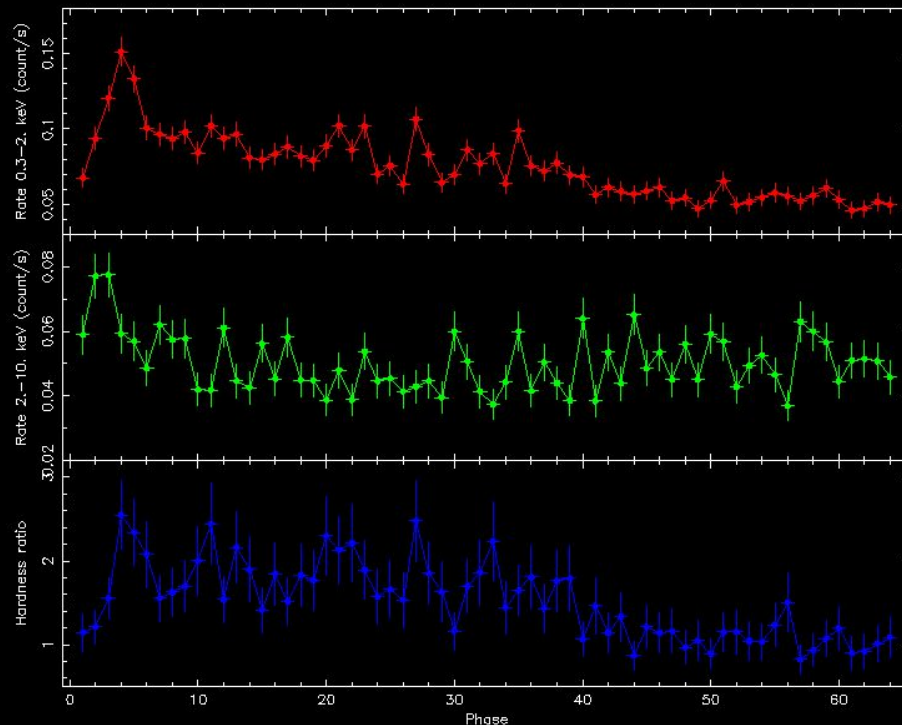
M51 ULX-7 Modulation Mean Profile



Mean profile of the modulation in the 0.3-2 keV band (red) and in the 2-10 keV band (green). Hardness ratio in blue.

Feature associated with the soft component of the spectrum?

No apparent evolution in the spectral parameters (consistent values in different phases of the modulation).



## SUMMARY AND PROSPECTS FOR THE FUTURE

- M51 ULX-7 persistent PULX with an easy-to-find pulsation. Evolving superorbital modulation of the flux.
- No 2.8 s pulsation detected in our observations. Recurring modulation at timescales  $\sim 2\text{--}3$  ks (absent in 2018). Similar feature observed by Chandra at the end of 2020.
- M51 ULX-7: recurring feature? What is the mechanism? Can it prevent us from observing the pulsation?
- (P)ULXs: other ULXs are known to show QPO in the PSD. M82 X-2 was one of them: new tool to identify new PULX candidates?





**SO LONG AND...**



*Thanks for all the fish!*