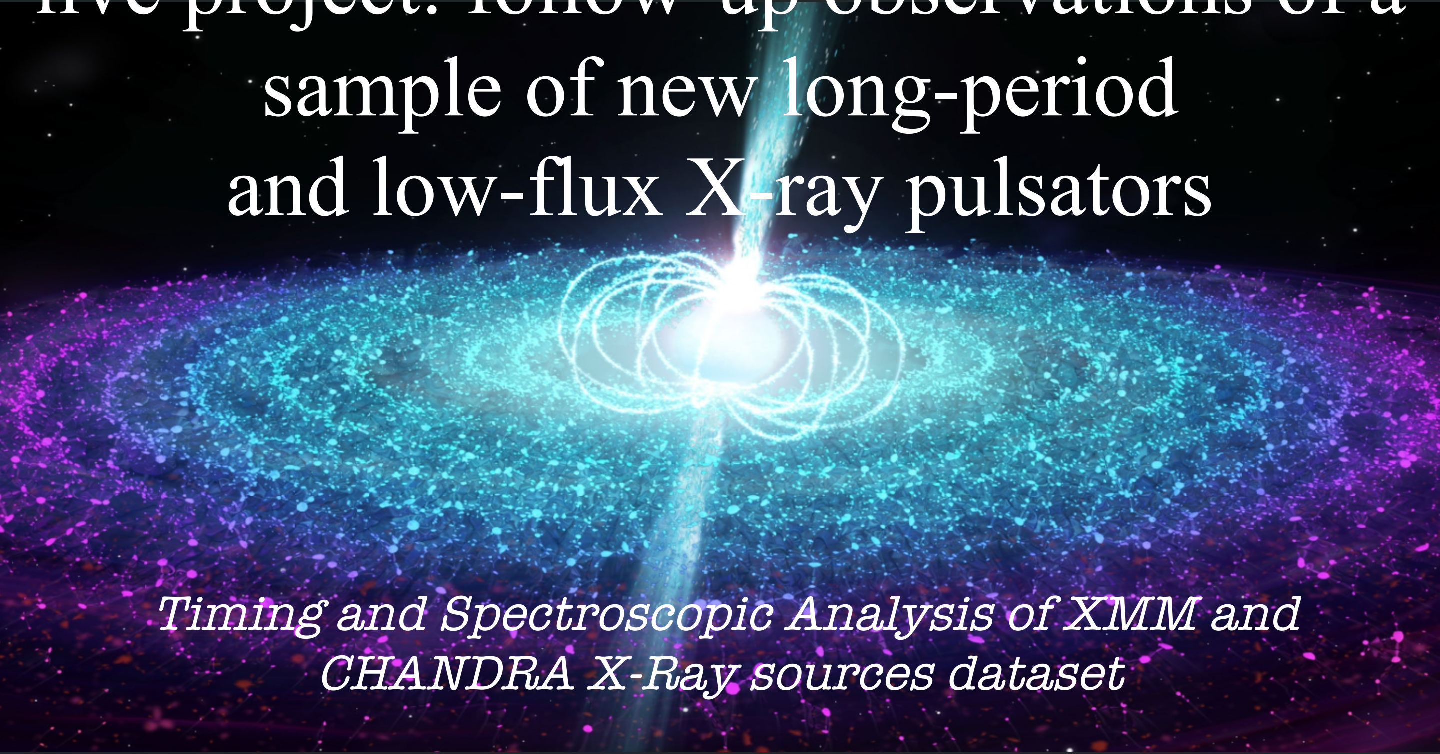
A reliability study of the CATS@BAR live project: follow-up observations of a sample of new long-period and low-flux X-ray pulsators



Timing and Spectroscopic Analysis of XMM and CHANDRA X-Ray sources dataset

CNOC XII
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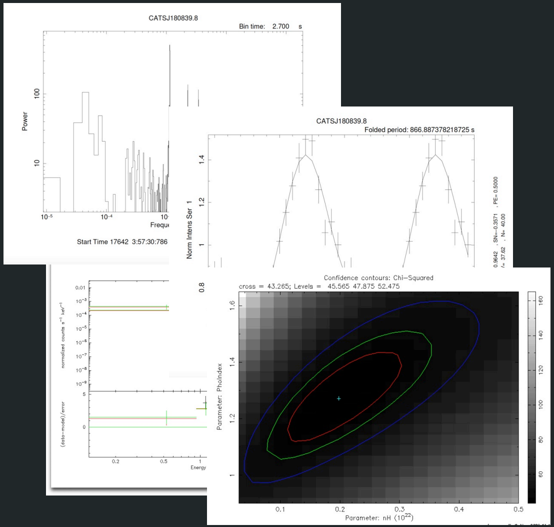
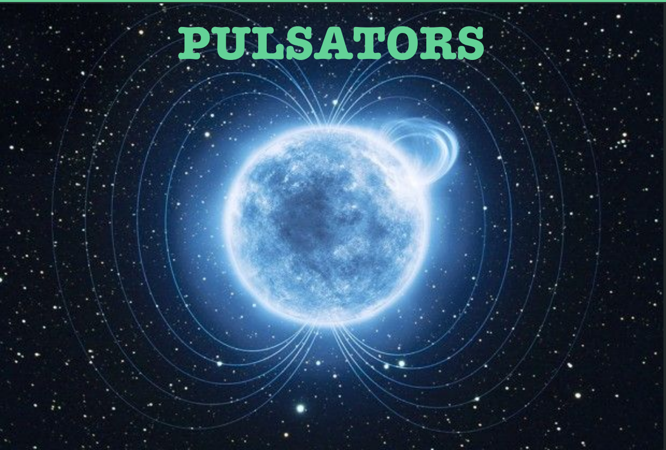
Supervisors: Prof Luigi Stella, Prof Gian Luca Israel

Outline:

- *What is a pulsator*
- *CATS@BAR catalog and sample*
- *Aims of the work*
- *Observations and data analysis*
- *Optical follow-up*
- *Conclusions*





PULSATORS

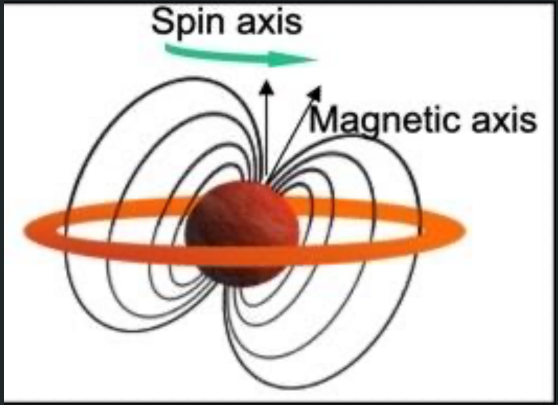
What are them?

compact objects whose variability is characterized by coherent periodicities

Why we study them?

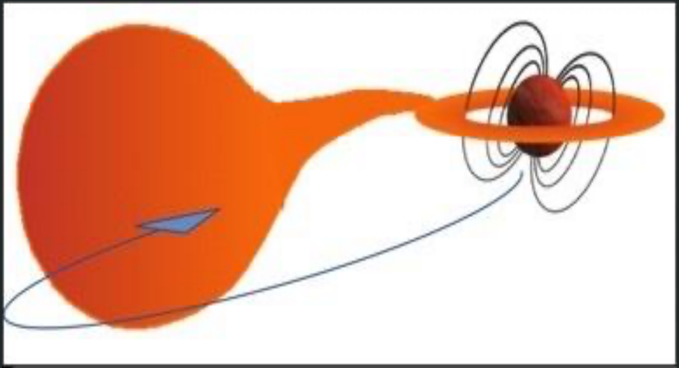
The detection and characterization of X-Ray signals is important to identifying new compact objects, studying their emission mechanism and also discovering new mechanisms.

The greatest part of coherent signals in the X-rays arise from the rotation of a compact star or from the orbital motion in a binary system

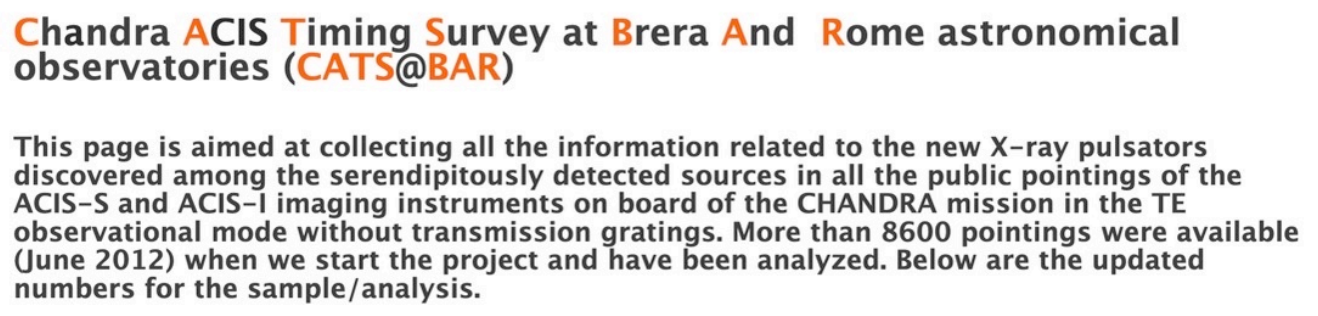


Rotation of stellar bodies:
spin periods
(minutes-hours)

Binary orbits:
[super-]orbital period
(WD, NS, BH)
(minutes-months)



CATS@BAR



Chandra ACIS Timing Survey at Brera And Rome astronomical observatories (CATS@BAR)

This page is aimed at collecting all the information related to the new X-ray pulsators discovered among the serendipitously detected sources in all the public pointings of the ACIS-S and ACIS-I imaging instruments on board of the CHANDRA mission in the TE observational mode without transmission gratings. More than 8600 pointings were available (June 2012) when we start the project and have been analyzed. Below are the updated numbers for the sample/analysis.

It's one of the largest ever systematic search for coherent signals in X-Ray band (until 2016, 190000 lightcurves out of about 430000 extracted). About 40 new X-ray pulsators detected
More than 50 per cent of them were confirmed by Chandra, XMM-Newton or ROSAT data.

Israel et al. 2016, The Chandra ACIS Timing Survey Project: glimpsing a sample of faint X-ray pulsators

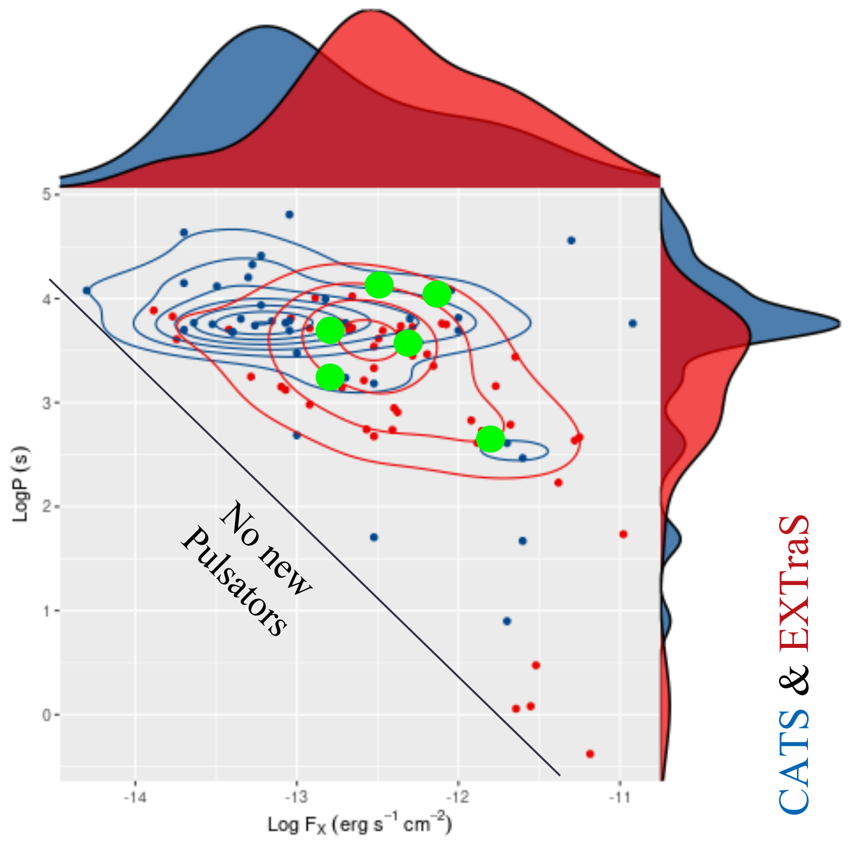
Missed pulsators?

No low-flux short-period new pulsators !

Likely related to magnetic gating and propeller effect (magnetic NSs) => high Mdot needed to have accretion ($r_m < r_{co}$) for short P

Warnings:

1) No known distances (Lx)
2) overabundance of CVs wrt NSs

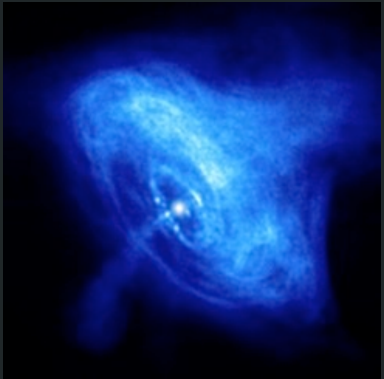


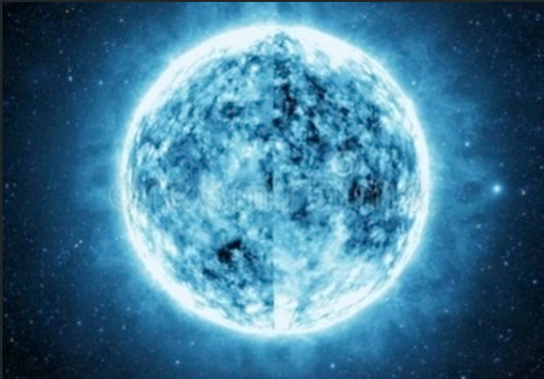
Goals of the work:

Starting from a sample of CATS@BAR pulsators and by means of X-ray follow-up observations, I tried to understand:

- If they are true signals or high power fluctuations
- If it is a pulsation, the signal origin:
  - *SPIN PERIOD (period change: NS)*
  - *ORBITAL PERIOD*
- Compact object nature: neutron star vs white dwarf

This information might be obtained through timing analysis and spectroscopic analysis





TIMING ANALYSIS workflow:

Sample: 6 sources with $854<P(s)<13151$ and $4E\text{-}14 < F_x(erg/cm^2/s) < 2.7E\text{-}12$

Data reduction from XMM and Chandra

Study of the light curve and search for peaks in the power spectrum through Fourier transforms using NASA's HEASARC HEASoft package

Estimation of the signal period and, if possible, refinement through the ***phase-fitting*** method

Study of the pulse shape and **pulsed fraction (PF)** and check for period variation

XMM/CHANDRA
TIMING ANALYSIS (preliminary):

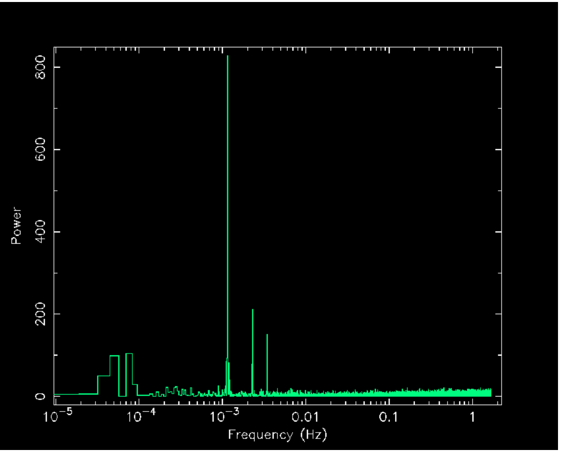
Source Name	**Mis.**	**Flag**	**Pnew(DeltaPnew)s**	**PF**	**Class.**
CXOUJ193437	X C	phasefit no new data	6136 (81) ----	29.97%	None
CXOUJ112347	X C	not visible phasefit	---- 1526.02090(7)	25.33%	Spin CV?
CXOUJ174728	X C	phasefit phasefit	4936 (1) 4935 (1)	85.42% 86.62%	Spin NS
CATS153539	X C	light curve no new data	10372 (235)	35.18%	Spin NS?
CATSJ063805	X C	light curve light curve	11075 (405) 13396 (264)	20.99% 71.94%	CV?
CATSJ180839	X C	phasefit phasefit	875 (1) 867(5)	42.41% 75.03%	Spin CV (optical Porb)

Meaning of period's colors:

- Pnew - Pcat < 1 sigma
- I sigma< Pnew - Pcat < 2 sigma
- 2 sigma < Pnew - Pcat < 3 sigma
- 3 sigma < Pnew - Pcat

ESA XMM-Newton Science Archive VS Chandra X-Ray Center

CATSJ180839

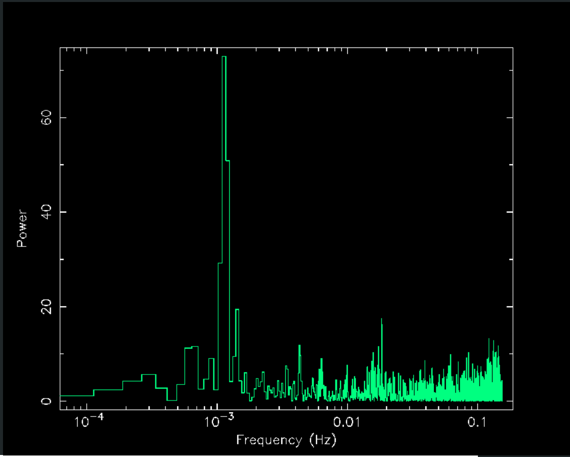


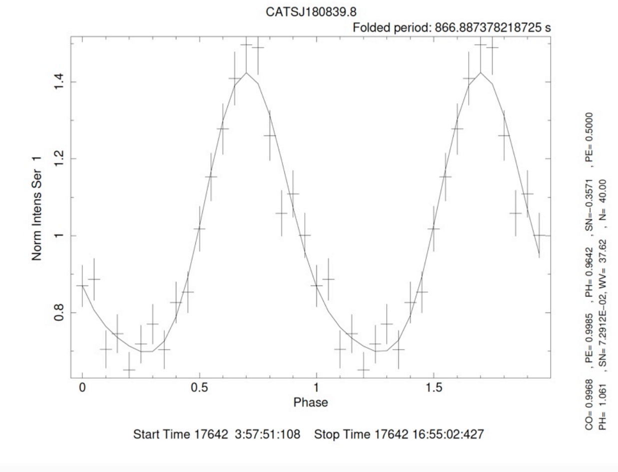
Flag:
phase fitting

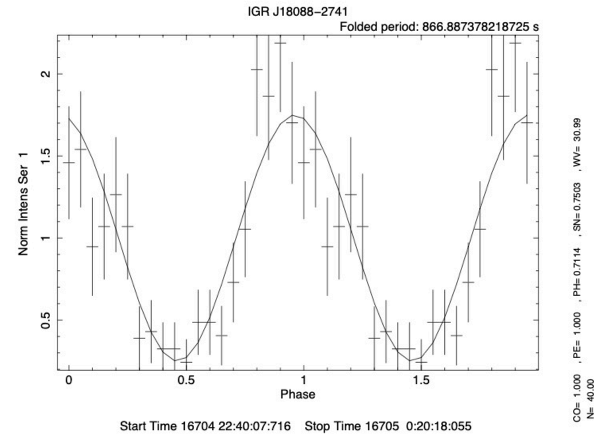
Period:
875 (0.6) s

Flag:
lcurve

Period:
873 (2) s





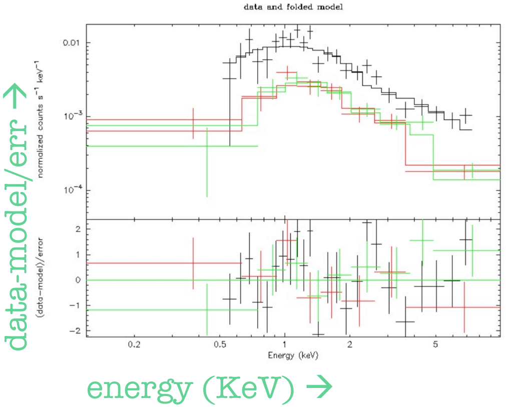


ESA XMM-Newton Science Archive

VS

Chandra X-Ray Center

CXOUJ193437



Model:

power law

Flux:

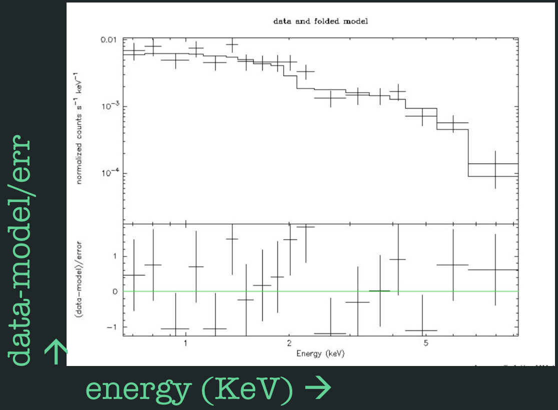
1.2785 e-13 ergs/cm²/s

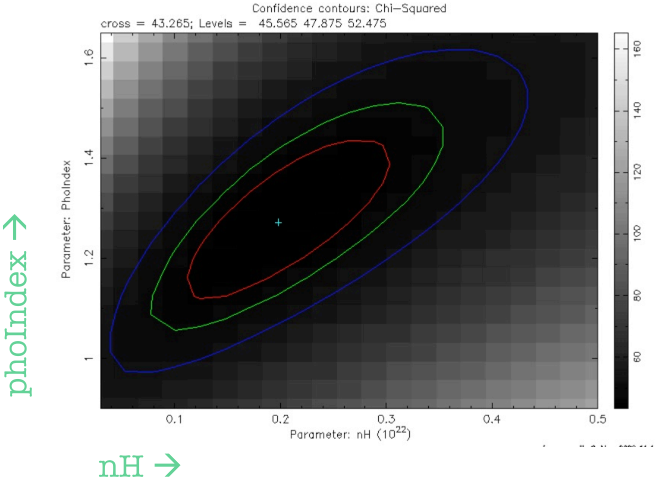
Model:

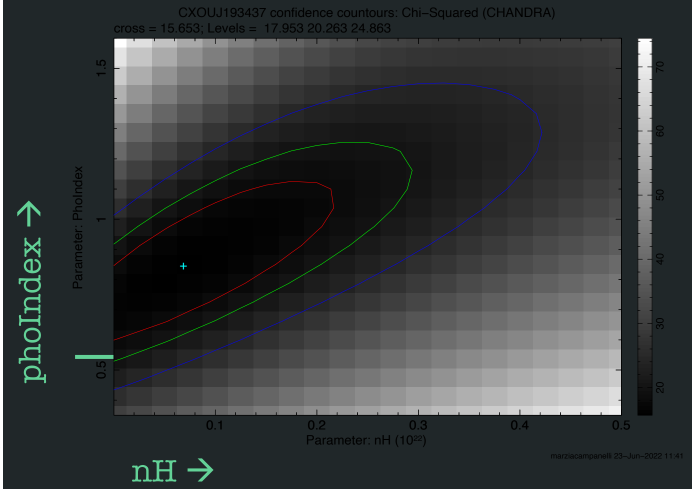
power law

Flux:

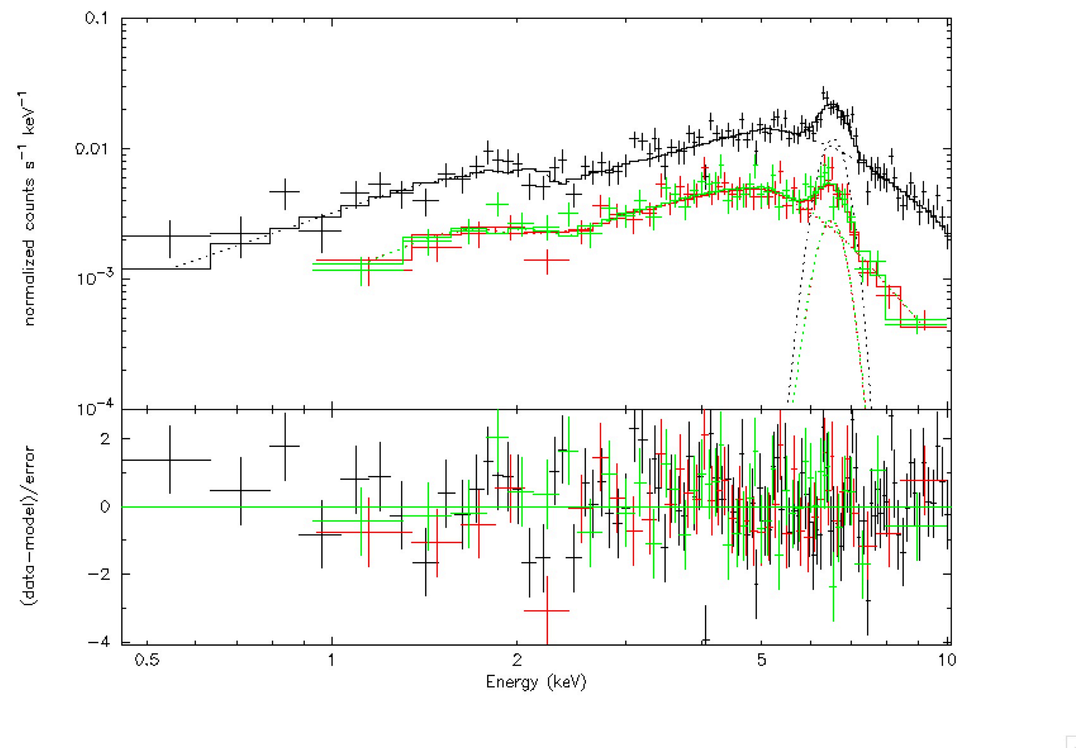
2.4463e-13 ergs/cm²/s







CATSJ180839 with XMM:

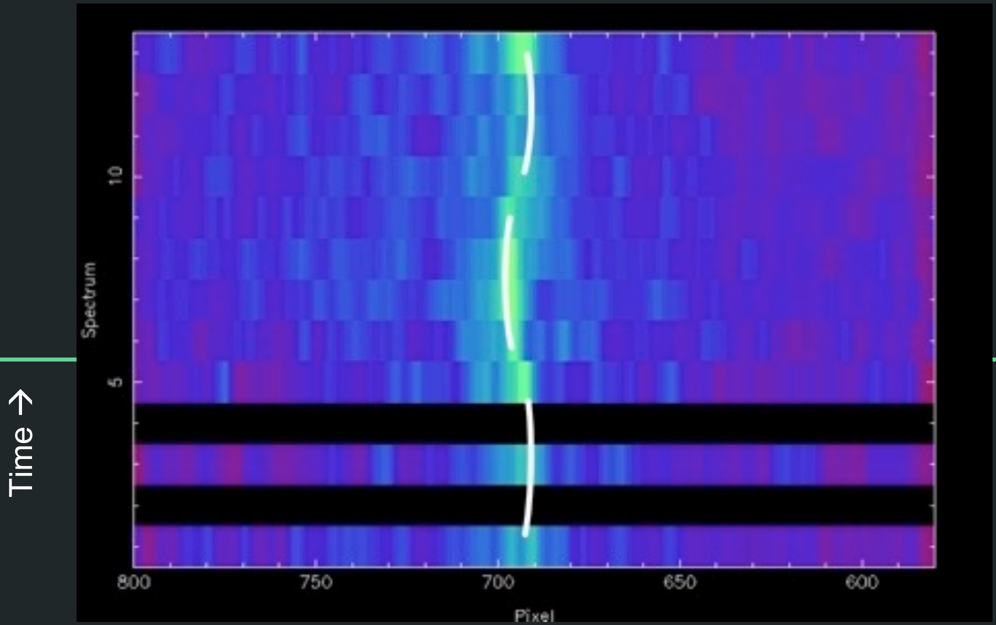


The presence of the iron line, together with the timing results, suggest the CV nature of the source

En iron line: 6.5(1)
EW ~ 1keV

Optical follow-up:

Optical spectroscopic observations may allow to distinguish between spin and orbital period, as we can see in the case of CXOUJ193437



Wavelenght →

Spectra taken by ALFOSC: UV-optical imaging polarimetry and low-resolution spectroscopy of the Nordic Optical Telscope

Conclusions:

- Owing to timing analysis, we classify some sources as NSs
- Spectral classification still on going (for CATSJ180839, likely CV)
- Time resolved optical spectroscopy used to infer the orbital nature of the X-ray signal in CXOUJ193437 (signal just above the detection threshold in CATS@BAR)

For the future:

- Others XMM observations on new long period low flux X-ray pulsars
- Optical observations with SIFAP2 and spectroscopic instruments

Thanks for the attention!

But, stay tuned because...