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Searching for more ultraluminous X-ray pulsars in the ULX population

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#### The aim

- Discovery of X-ray pulsations from M82 X-2, NGC 7793 P13, NGC 5907 X-1, NGC 300 ULX-1 and M51 ULX-7 + M51 ULX-8;
- Adopt a simple <u>phenomenological</u> spectral model, extensively used to fit the X-ray continuum of accreting magnetic NSs, especially X-ray pulsators in Galactic high mass X-ray binaries:

#### highecut\*powerlaw + (diskbb?)

$$M(E) = \begin{vmatrix} exp \left[ (E_c - E) / E_f \right] & E \ge E_c \\ 1.0 & E \le E_c \end{vmatrix}$$

# Selection of the sample

- Bright ULXs
- High quality data
- Well monitored sources with XMM or NuSTAR
- For each source, the two most extreme spectral states are taken

NGC 5408 X-1	NGC 1313 X-1	NGC 6946 X-1
NGC 55 ULX-1	<u>NGC 5907 X-1</u>	HO II X-1
NGC 5204 X-1	<u>NGC 7793 P13</u>	HO IX X-1
NGC 1313 X-2	NGC 5643 X-1	IC 342 X-1

### Spectral results



Very good fit in all cases (although some exceptions).

The ULXs in the sample present a marked hard to soft evolution.

### Spectral results



#### Black hole based models do not necessarily have the interpretative power attributed to them!



The ULXs in the sample present a marked hard to soft evolution.









# Search for other ULX pulsars

- Pulsations! Cyclotron lines!
  Transient ULXs?
- Spectrally hard ULXs?

-(ULXs with high short-term variability?)-(Very bright ULXs?)

### Transient: NGC 5907 ULX-2



Pintore et al. (2018)

#### Outburst LC







Color-Color diagram



Color-Color diagram





#### Bright and variable: NGC 925 ULX-1 and ULX-2



Distance = 8.9 Mpc

# Light-curve



# Spectral fits



tbabs x (HIGHECUT x POWERLAW)

tbabs x POWERLAW





#### Conclusions

- The bright ULX spectra can be equally well fitted by models for NSs and BHs;
   We cannot discriminate the existence of NSs or
  - BHs from the spectral model only;
- Are PULXs really harder than the rest of the ULX population?
- **Can we find NSs in ULXs on the basis of this spectral feature?**
- **Motion** Amongst the new ULXs, I suggest that NGC 925 ULX-1 may be one good candidate to host a NS.

#### Thanks for the attention