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A BROADBAND NICER+NUSTAR OBSERVATION OF NGC 4190 ULX-1

Hannah Earnshaw (Caltech)

Pronouns: they/them/their

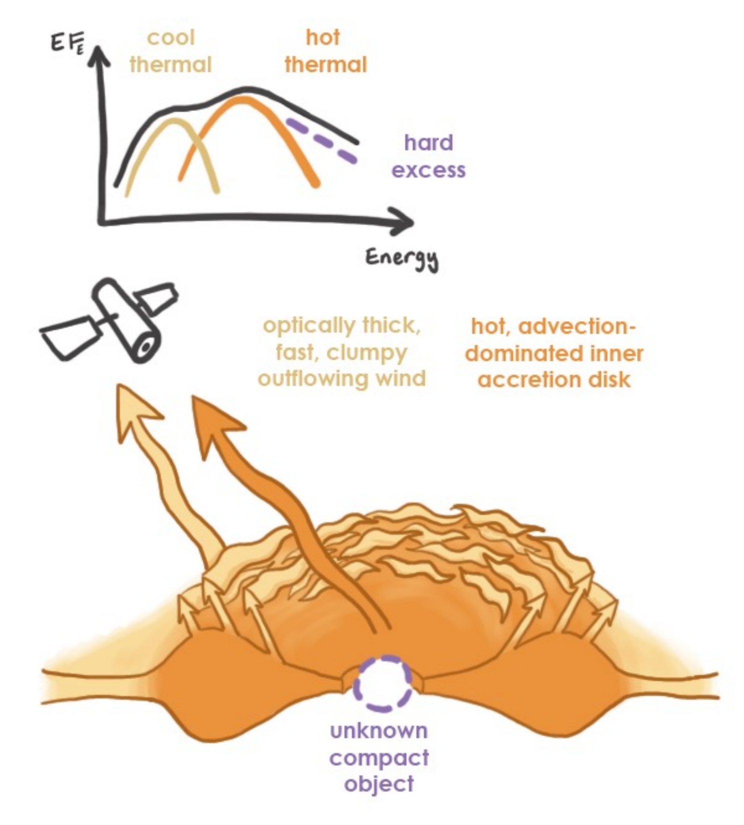
M. Bachetti, M. Brightman, F. Fürst, B. Grefenstette, F. Harrison,
A. Jaodand, R. Ludlam, M. Middleton, D. Stern, D. Walton

Caltech

hpearn@caltech.edu

ULTRALUMINOUS X-RAY SOURCES

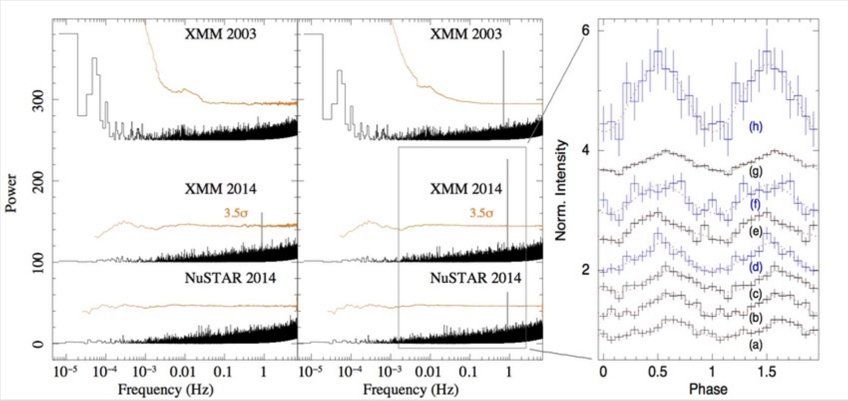
- What are ULXs?
  - Extremely luminous (>10^{39} erg/s), off-nucleus extragalactic (mostly) X-ray sources
  - Stellar-mass black holes or neutron stars accreting above their Eddington limit: probes of the most extreme accretion physics
  - Emission comes from hot, supercritical accretion disc and massive, fast outflowing wind
  - Potential analogues to early-Universe super-Eddington accretion, GW event precursors

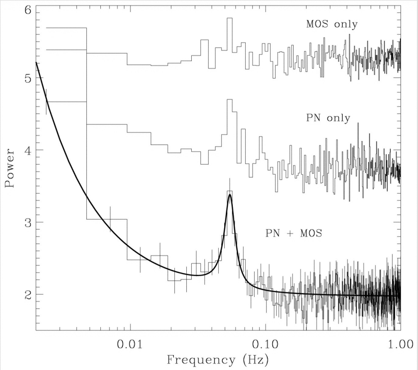


SHORT-TERM VARIABILITY OF ULXS

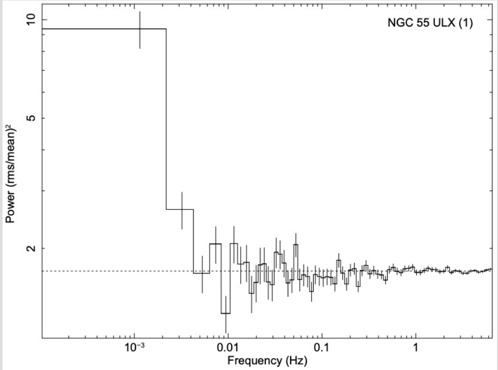
- Several ULXs have been identified as containing neutron star accretors from the detection of X-ray pulsations
  - Most ULX pulsations have period ~1–10s with sinusoidal pulse profiles, exhibit significant spin-up, increase in pulsed fraction with energy, and may be transient
- A handful of ULXs exhibit quasi-periodic oscillations (QPOs) — most have featureless power spectra, sometimes with red noise at low frequencies from accretion processes

NGC 5907 ULX-1 – Israel et al. (2017)



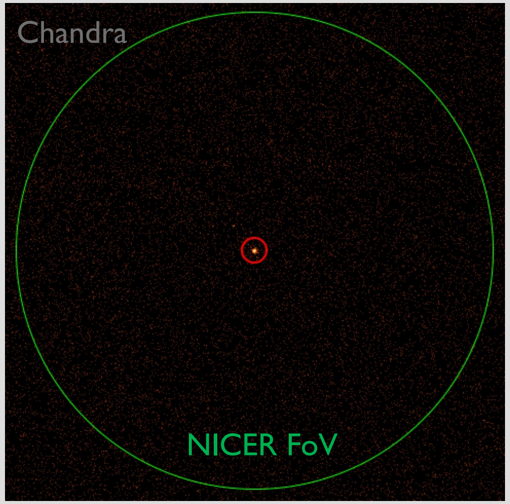


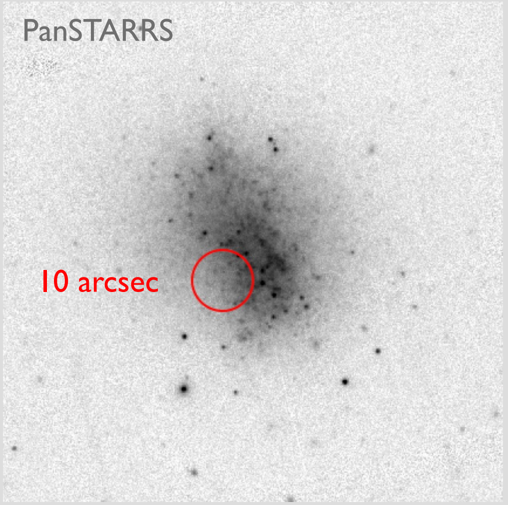
M82 ULX-1 – Strohmayer & Mushotzky (2003)

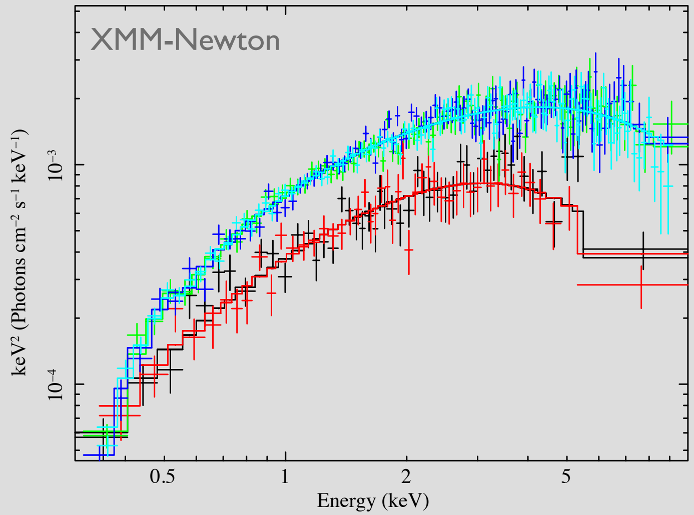


NGC 55 ULX – Heil et al. (2009)

NGC 4190 ULX-1: AN IDEAL NICER+NUSTAR TARGET



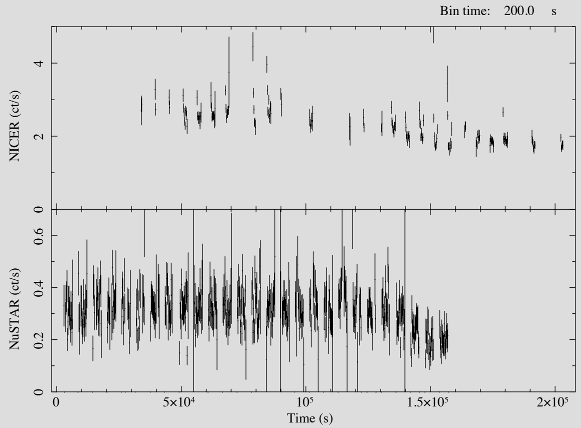


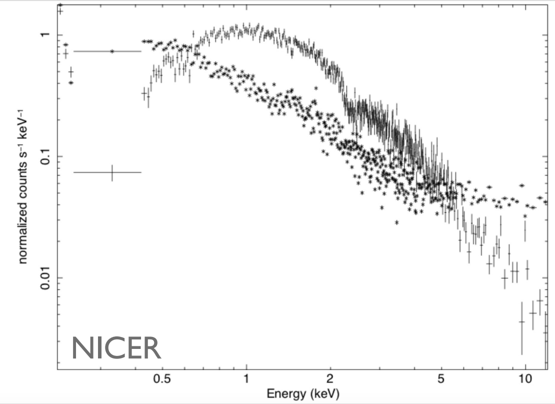


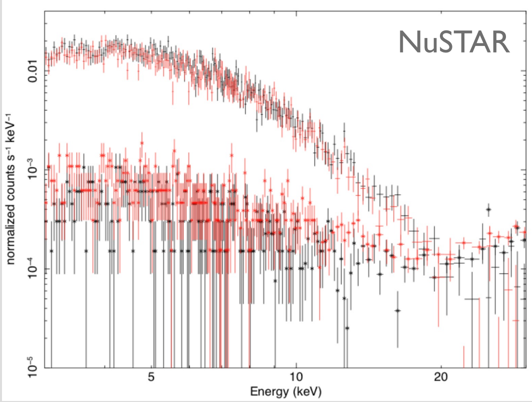
- Isolated source in a low-surface brightness galaxy at ~2.9 Mpc
- Flux is high (2–6 x 10^{-12} erg/cm^2/s), interesting spectral behaviour

NGC 4190 ULX-1

- Joint observation in April 2020:
  ~25ks NICER, ~73ks NuSTAR good time
  (~77k NICER cts, ~15k NuSTAR cts)
- Source is bright throughout the observation, with a slight decrease in flux towards the end
- Analyzing:
  - NICER data between 0.5 and 4.7 keV
  - NuSTAR data between 3 and 20 keV

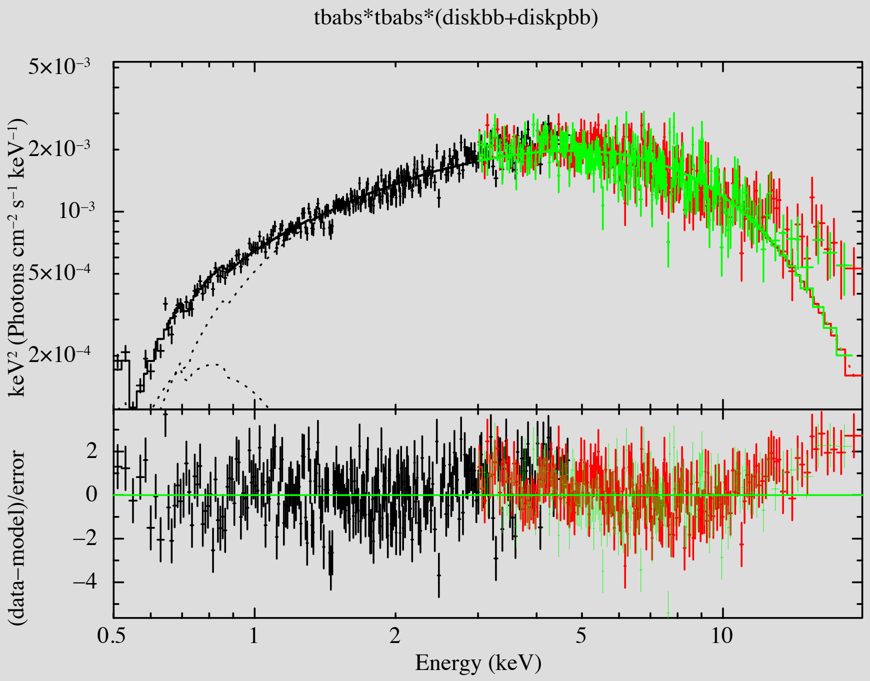






NGC 4190 ULX-1 SPECTRUM

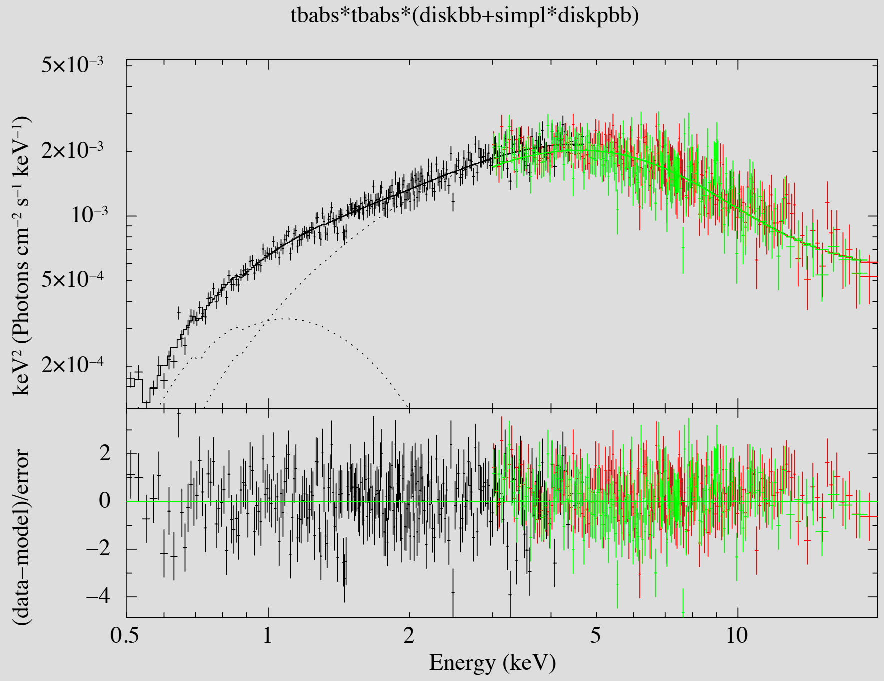
- Joint spectrum can be fitted with two thermal components (diskbb+diskpbb) plus either a cut-off powerlaw or simpl tail



Clear hard excess seen at >10 keV

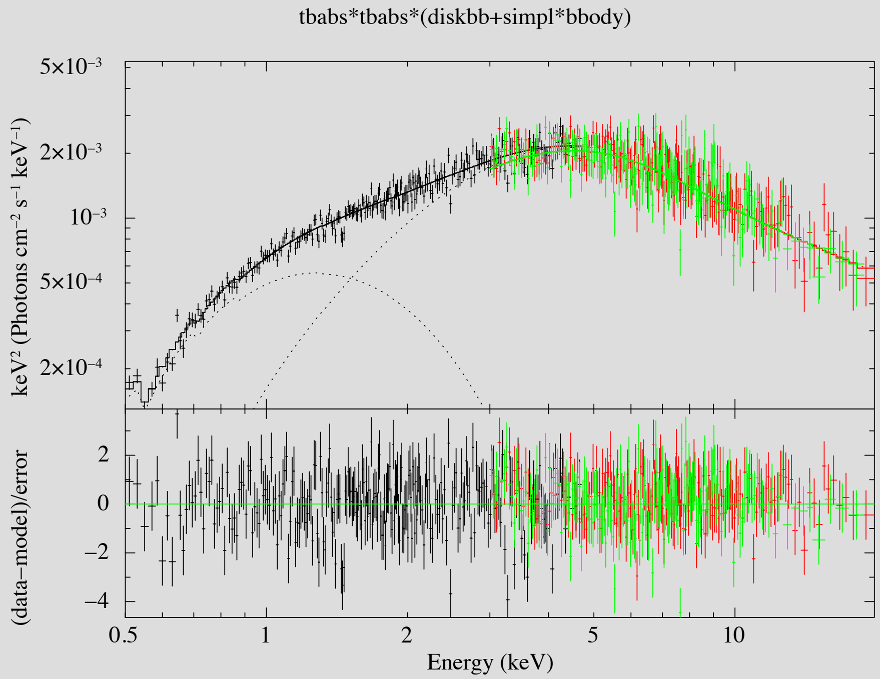
NGC 4190 ULX-1 SPECTRUM

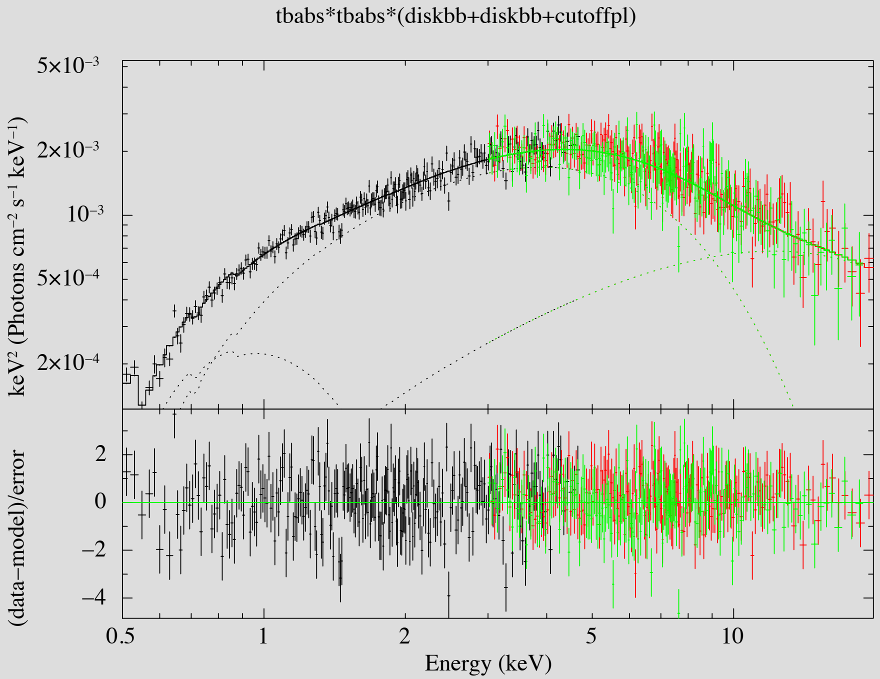
- Joint spectrum can be fitted with two thermal components (diskbb+diskpbb) plus either a cut-off powerlaw or simpl tail
- When the hard excess is accounted for, though, the hot thermal component is no longer required to be broadened – better fit with diskbb or simple blackbody



$T_{in,diskbb}$ = 0.32±0.04 keV
$T_{in,diskpbb}$ = 1.5±0.2 keV, p > 0.84
Γ_{simpl} = 2.4±0.5, F_{sc} = 0.3±0.1, χ^2 = 1001.3 / 783

NGC 4190 ULX-1 SPECTRUM



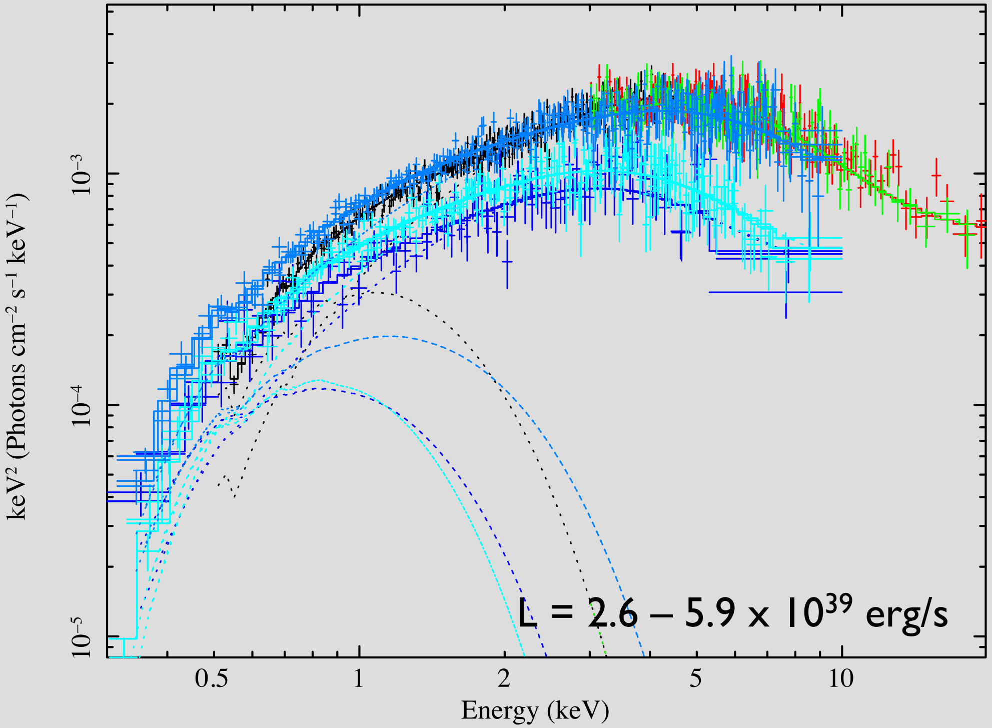


$T_{in,diskbb}$ = 0.44±0.05 keV
kT_{bbody} = 0.93±0.06 keV
Γ_{simpl} = 2.9±0.2, F_{sc} = 0.5±0.1, χ^2 = 998.1 / 784

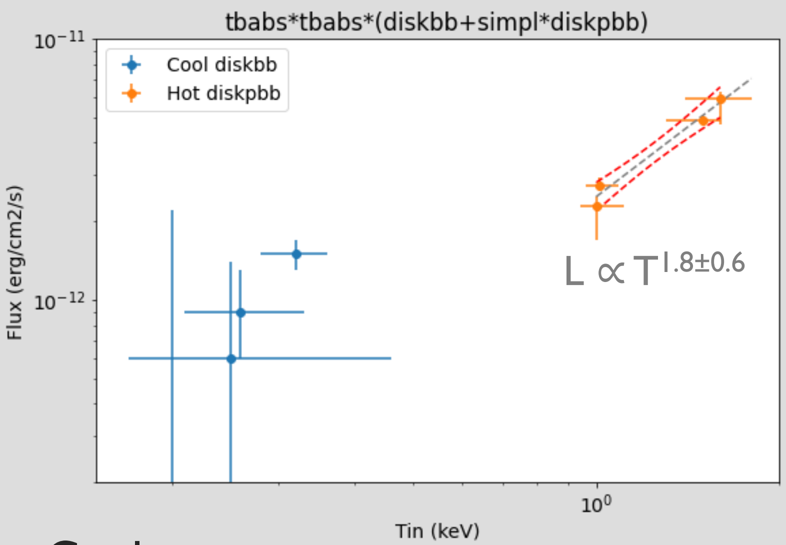
$T_{in,diskbb1}$ = 0.24±0.03 keV
$T_{in,diskbb2}$ = 1.62±0.05 keV,
$\Gamma_{cutoffpl}$ = 0.5, E_{cut} = 8.1 keV (frozen), χ^2 = 983.0 / 785

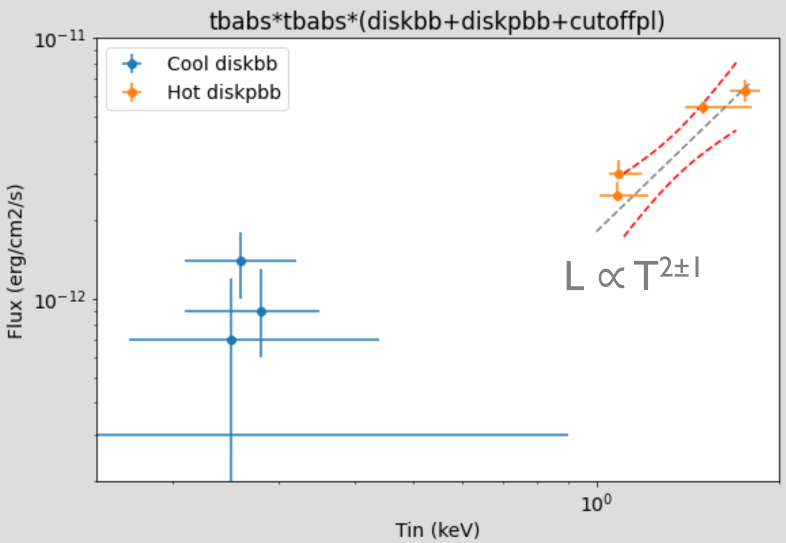
ARCHIVAL SPECTRA

- Archival XMM-Newton observations show similar spectral behavior, so we can try fitting the same models
- We freeze simpl and cutoffpl model parameters to fitted NICER+NuSTAR values (except for cutoffpl normalization)



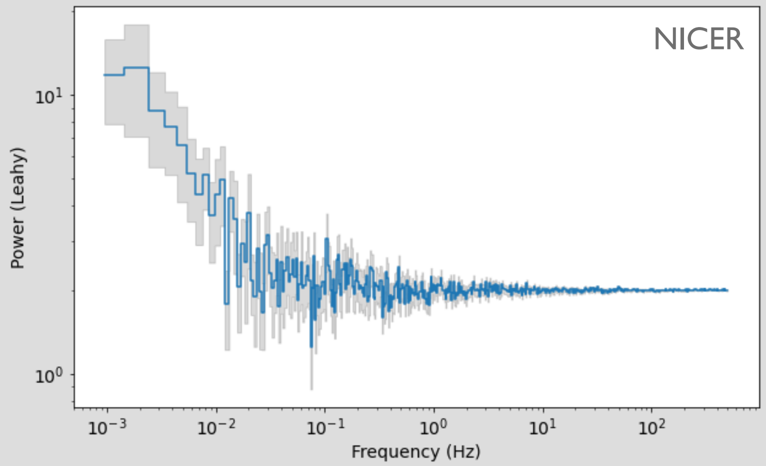
L-T RELATION

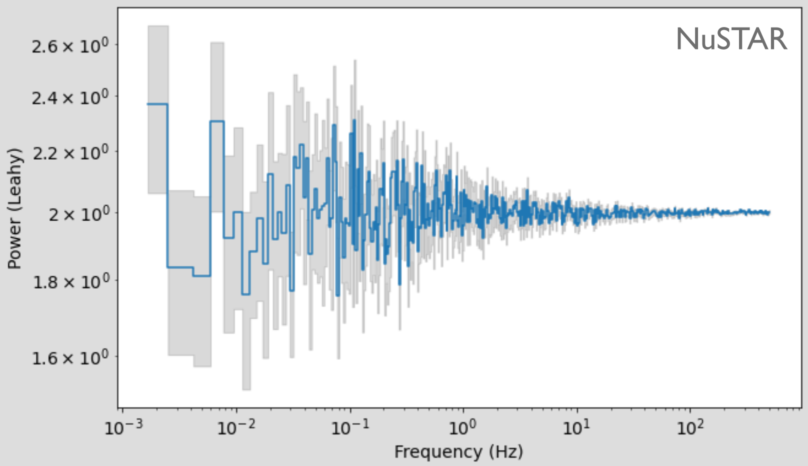




- Cool component parameters are not well constrained, but hot component demonstrates a luminosity-temperature relation more consistent with advection-dominated relation ($L \propto T^2$) than with a standard black body disk ($L \propto T^4$)

POWER SPECTRUM





- Power spectrum is featureless aside from red noise at low frequencies in NICER waveband, consistent with accretion processes
- No evidence for QPOs or peaks indicating the presence of coherent pulsations

PULSATION SEARCH

- We ran accelerated pulsation searches using HENDRICS between 0.01 and 10 Hz, with fdot from 0 to 1e-9 Hz/s
  - No pulsations were detected ☹
  - By simulating pulsed light curves over the same GTIs, we can place 90% upper limits on the pulsed fraction of ~16% in NICER band and ~35% in NuSTAR band
  - Weak pulsations are not entirely ruled out—ULX pulsations may also be transient

IMPLICATIONS

- A broadened disk spectrum is not preferred when fitting the broadband spectrum, but the L-T relation is more consistent with an advection-dominated slim disk than with a standard thin accretion disk
- Luminosity is too high for this inner disk to be a sub-Eddington thin disk around a black hole, as the inferred black hole mass from R_{in} (~10 $M_\odot$) requires the source to be undergoing super-Eddington accretion
- Potentially a supercritical slim disk truncated by a moderate-strength magnetic field? We do not (yet) have a pulsation detection to back this up
- This is a good source for future follow-up observations!