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

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Pronouns: they/them/their

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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)


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 × 10^{-12} erg/cm²/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

$T_{\text{in, diskbb}} = 0.32 \pm 0.04$ keV
$T_{\text{in, diskpbb}} = 1.5 \pm 0.2$ keV, $p > 0.84$
$\Gamma_{\text{simpl}} = 2.4 \pm 0.5, F_{\text{sc}} = 0.3 \pm 0.1, \chi^2 = 1001.3 / 783$
NGC 4190 ULX-1 SPECTRUM

\[ T_{\text{in,diskbb}} = 0.44 \pm 0.05 \text{ keV} \]
\[ kT_{\text{bbody}} = 0.93 \pm 0.06 \text{ keV} \]
\[ \Gamma_{\text{simpl}} = 2.9 \pm 0.2, F_{\text{sc}} = 0.5 \pm 0.1, \chi^2 = 998.1 / 784 \]

\[ T_{\text{in,diskbb1}} = 0.24 \pm 0.03 \text{ keV} \]
\[ T_{\text{in,diskbb2}} = 1.62 \pm 0.05 \text{ keV} \]
\[ \Gamma_{\text{cutoffpl}} = 0.5, E_{\text{cut}} = 8.1 \text{ keV (frozen)}, \chi^2 = 983.0 / 785 \]
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).

\[
L = 2.6 \times 10^{39} \text{ erg/s}
\]
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 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
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
• 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 $R_{\text{in}}$ ($\sim 10 \, M_\odot$) 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!