Bright Meals for Light Eaters: Analysis and Characterization of Ultraluminous Accreting X-ray Binaries in the Local Universe

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INTRODUCTION

➔ **Observations of X-ray sources in nearby galaxies provide the best opportunities to study both neutron stars (NSs) and black holes (BHs).**

- ◆ These compact objects often form binary systems with stars, their gravity slowly pulling material from the star's surface
- ◆ This creates an *accretion disk* of stellar material about the compact object, orbiting at a significant fraction of the speed of light
- ◆ This energetic material emits X-rays, which we observe with X-ray telescopes like *Chandra*

➔ **Emission from these X-ray binaries (XRBs) allows us to study the effects of compact objects on their environment, as well as the physics evolved in their emission.**

- ◆ XRBs are known to exist in distinct X-ray emission states related directly to the compact object's mass accretion rate
- ◆ Sources cycle through these states over time, and observing a full cycle would allow a determination of the nature of the compact object as either a NS or BH
- ◆ Timescales for emission cycles for XRBs can range from days to decades, making detailed analysis viable only for small samples

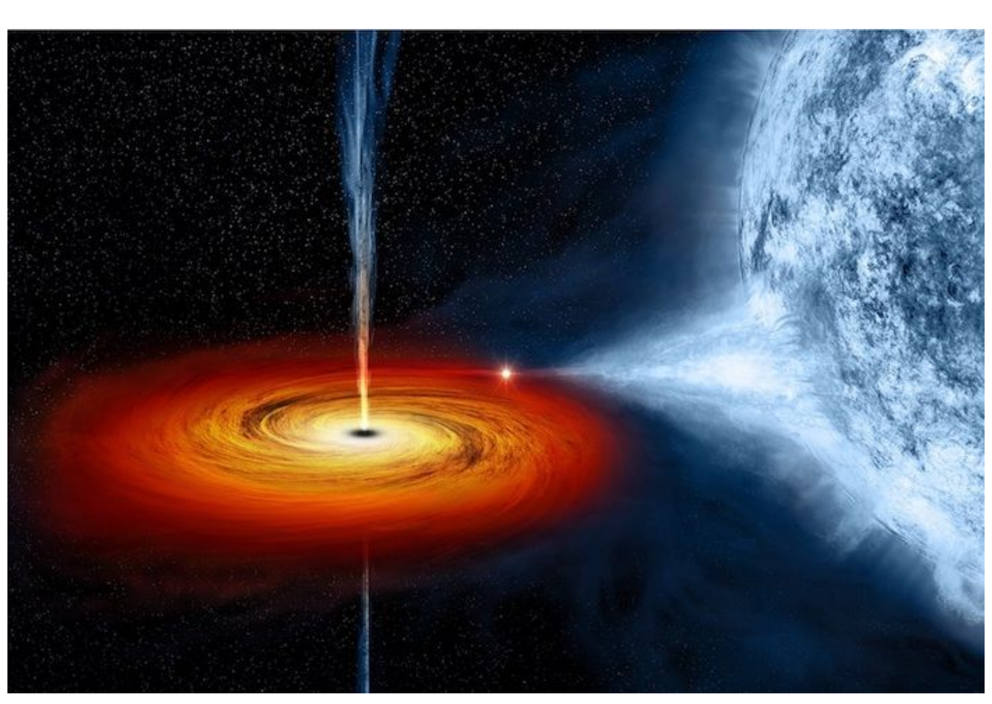

***Fig. 1**: Artist's interpretation of a black hole binary feeding on its companion star. (NASA/CXC/M. Weiss)*

SAMPLE

➔ Sources in the sample from Professor Kilgard's database of ~45,000 *Chandra* observations of bright X-ray sources in galaxies in the local universe

➔ Initial sample comprised of sources from this database with >2,000 counts, yielding 78 objects representing ~0.66% of the total sources

➔ Final sample of 47 sources after filtering for extremely distant galaxies, background AGN, nuclear sources and confirmed non-XRB objects.

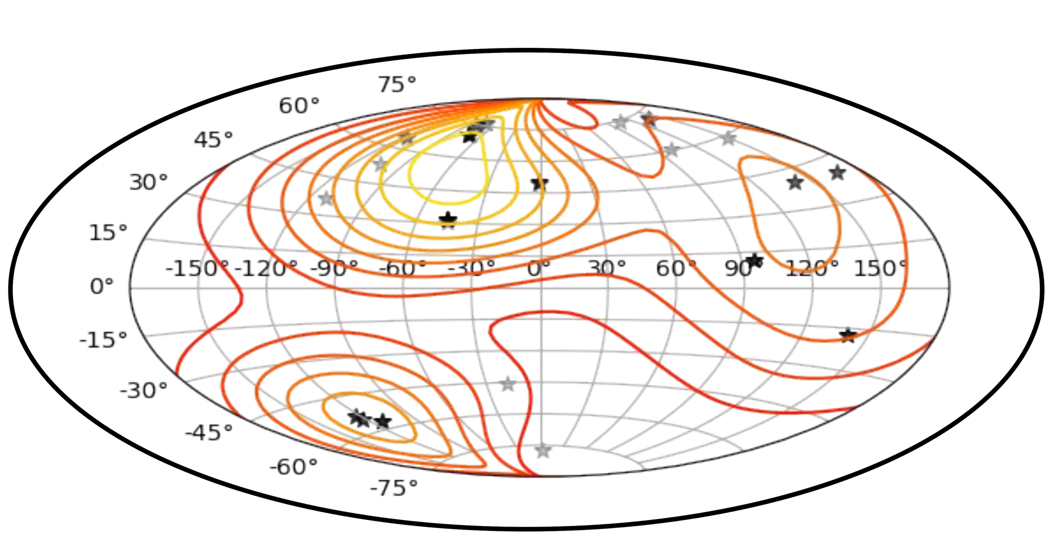

Fig. 2: *Scatter plot of the initial sample of 78 sources.* Temperature lines indicate density of sources.

METHODS & ANALYSIS

➔ Extracted lightcurves, spectral fits for each source in the sample

- ◆ Narrowed down well-fitting models using the algorithm outlined in Figure X
- ◆ Each source fit with 31 unique combinations of models in Table 1
- ◆ Lightcurves with distinct periods of brightness over the course of the observation split into epochs and fit separately

Model	Description	Component
tbabs	ISM grain absorption	Intergalactic absorption
mekal	Hot, diffuse gas emission	Generic hot gas
powlaw1d	One-dimensional power-law emission	Corona
compbb	Comptonized blackbody emission	Corona
diskbb	Multi-temperature accretion disk blackbody emission	Accretion disk
diskpn	Multi-temperature accretion disk blackbody emission	Accretion disk
apec	Collisionally-ionized plasma / diffuse gas emission	Accretion disk

***Table 1**: Description of subcomponents included in considered spectral models.*

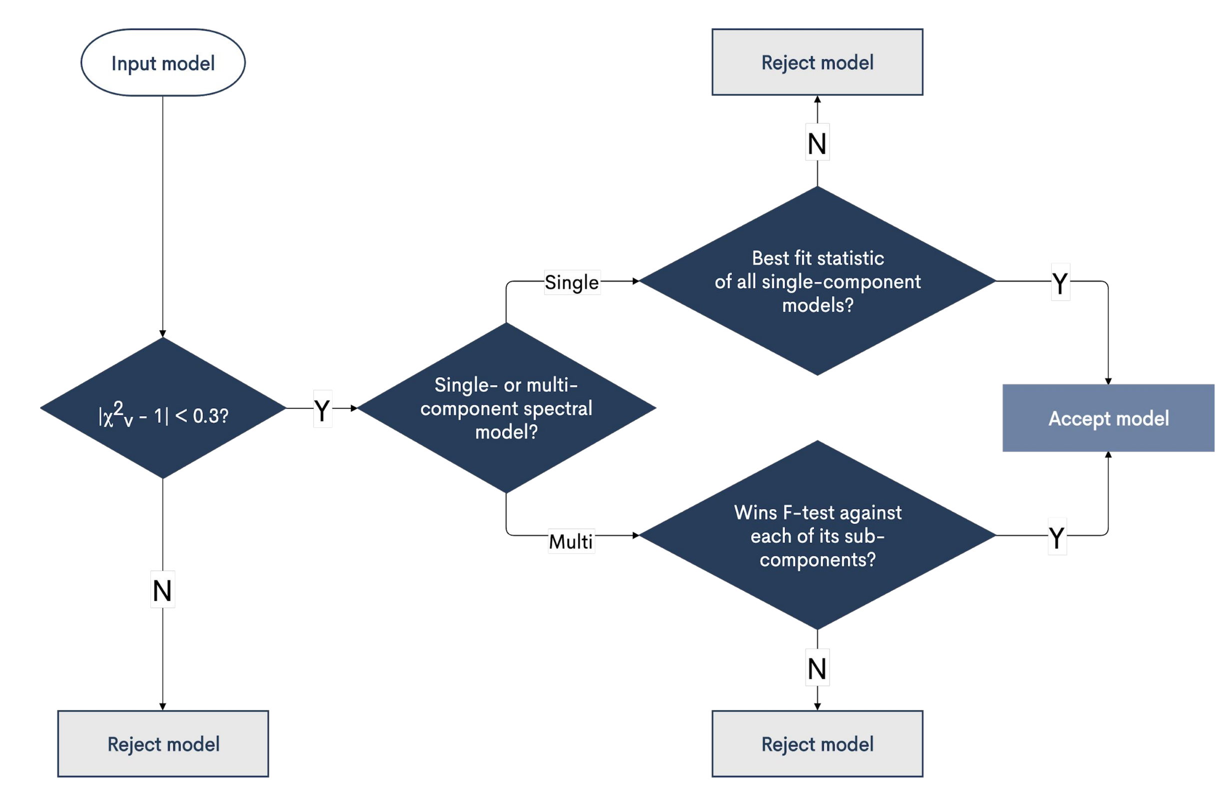

***Fig. 3**: Visual representation of the ACAB algorithm.*

➔ Hand-selected final fits for each source by feasibility of parameters, fit statistic, and visual goodness of fit

➔ Sources with unusual variability or poorly fit spectra set aside for more detailed analysis

RESULTS & CONCLUSIONS

➔ Of the 47 sources in the final sample...

- ◆ Preliminary fits determined for 41 sources
  - Six sources resistant to the ACAB algorithm require hand-fitting in the future
- ◆ Five sources of particular interest set aside for follow-up
  - One source presumed to be transitioning between spectral states over the course of an observation (Fig. 4)
  - One source exhibits signs of quasiperiodicity
  - Three sources exhibit lightcurves unusual for less obvious reasons

➔ **Future work** includes follow-up for sources of interest above

- ◆ Optical search for companion stars (Hubble, VVO)
- ◆ HR analysis to further constrain spectral state

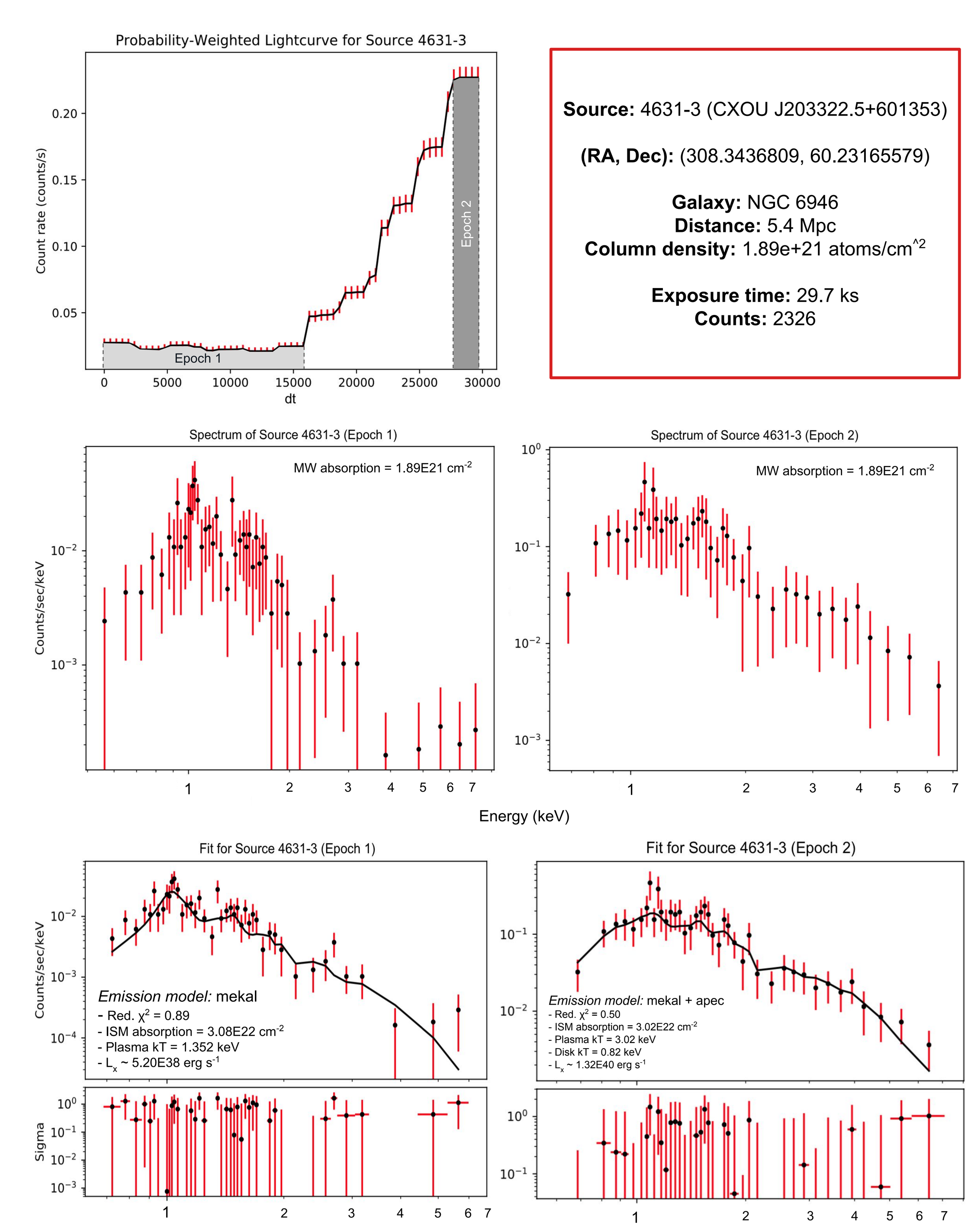

***Figure 4**: Lightcurve, <Hubble image/HR plot>, spectra and preliminary fits for Source 4631-3 in NGC 6946.* The lightcurve shown in the upper left panel indicates that the source went through a period of rapid brightening, prompting a split into a dim regime (Epoch 1) and a bright regime (Epoch 2). The spectra of these regimes were re-extracted separately, (mid panels) highlighting an obvious difference in emission. Preliminary fits for these spectra are shown (lower panels). Further analysis is necessary.

TL;DR

78 ***Chandra observations of bright sources in local galaxies***

47 ***Spectra fit with thermal emission models***

31 ***Individual spectral models considered for each source***

15 ***Suspected serendipitous observations of new ULXs***

5 ***Sources of interest poised for follow-up***

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