

Connections Between the Radio Jet and X-Ray Corona in Black Hole Low-Mass X-Ray Binaries

Charlotte Johnson^{1,2}, Anne Lohfink, PhD²
¹University of South Carolina Columbia, ²Montana State University

Abstract

Black hole low-mass X-ray binaries (LMXBs) are characterized by a black hole (BH) accreting matter from their low-mass companion star. They occasionally experience outbursts, defined by periods of increased accretion of matter and emission. As an outburst progresses, changes to the structures around the BH are observed. However, these changes are not yet entirely understood. We present an investigation of 3 BHs as they progress through the outbursts to establish a stronger connection between the BH radio jet and the X-ray corona. We analyze archival X-ray data from both *RXTE* and *Swift* for each source paired with archival radio data. Among the studied sources we find evidence that the radio jet and X-ray corona could be physically connected.

Background and Introduction

During outbursts, we observe the BH radio jet transition from a continuous outflow (compact jet), to distinct plasma ejections (transient jet). There are nearly simultaneous changes in the X-ray emission, which could be indicative of a causal connection between the radio jet and X-ray source, the X-ray corona. We aim to test this idea through comparison of the X-ray coronal height above the BH and radio jet base location. If these components are observed to evolve in a correlated fashion, this could point to a physical connection between the two.

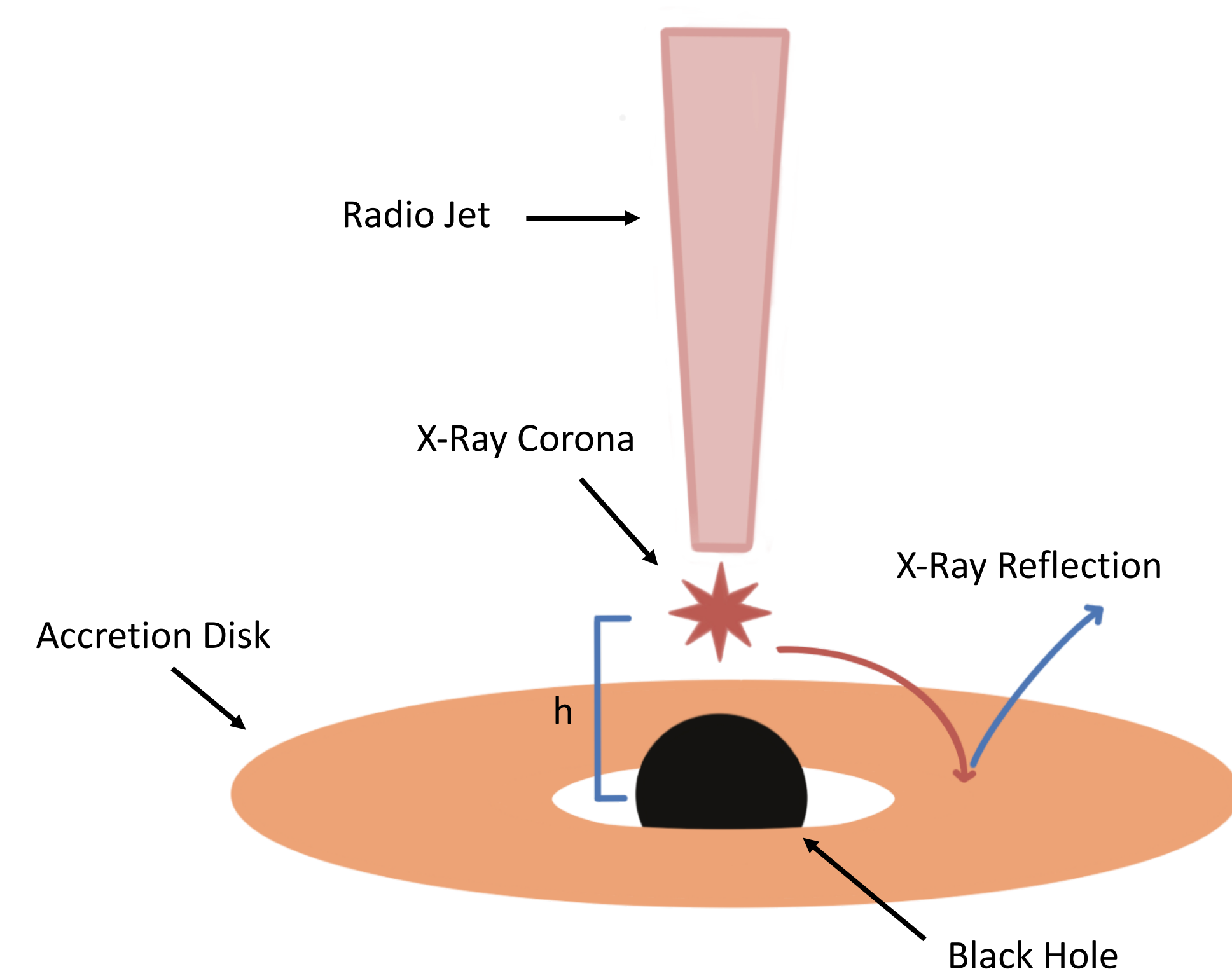


Figure 1. Black hole diagram.

Sources and Data

We use X-ray spectral data to learn about the position of the X-ray corona and radio data to understand the nature of the jet. Archival X-ray data from the *Ross X-ray Timing Explorer (RXTE)* Proportional Counter Array (PCA) instrument (3-25 keV coverage) and the *Neil Gehrels Swift Observatory X-Ray Telescope (XRT)* (0.5-10 keV coverage) is analyzed. Radio data is taken from the literature for each BH outburst (MAXI J1836-194 from [1], H1743-322 from [2], GX 339-4 from [3]).

Target	Outburst
MAXI J1836-194	Sept. 2011
GX 339-4	Jan 2010 - Mar 2011
H1743-322	May - Aug 2009

X-Ray Spectral Analysis

To track the X-ray corona location, we describe the X-ray spectra with several models including the **relxillp** [4] model which describes X-ray reflection off the accretion disk from a point source corona. One parameter in this model is the corona height, where more disk reflection results from a lower corona closer to the BH. Additionally, the models **diskbb** [5] and **Tbabs** [6] are included to account for the accretion disk emission and galactic absorption along the line of sight, respectively. The X-ray spectral analysis is done in the X-ray spectral fitting package, XSPEC [7]. We perform chi-squared modeling and perform an error calculation at the 90% confidence level.

Radio Spectral Index

We use the radio spectral index, α , to determine the nature of the jet. A positive spectral index corresponds to a compact jet, while a negative spectral index indicates a transient jet [8]. By comparing the transition of the index from positive to negative to the observed changes in the X-ray coronal height, we determine if there is a physical connection between the BH components.

Results

In all figures below, red points correspond to where only *RXTE* data was available, blue corresponds to only *Swift* data available, and green indicates a joint analysis with data from both. Shaded regions indicate the X-ray hard spectral state.

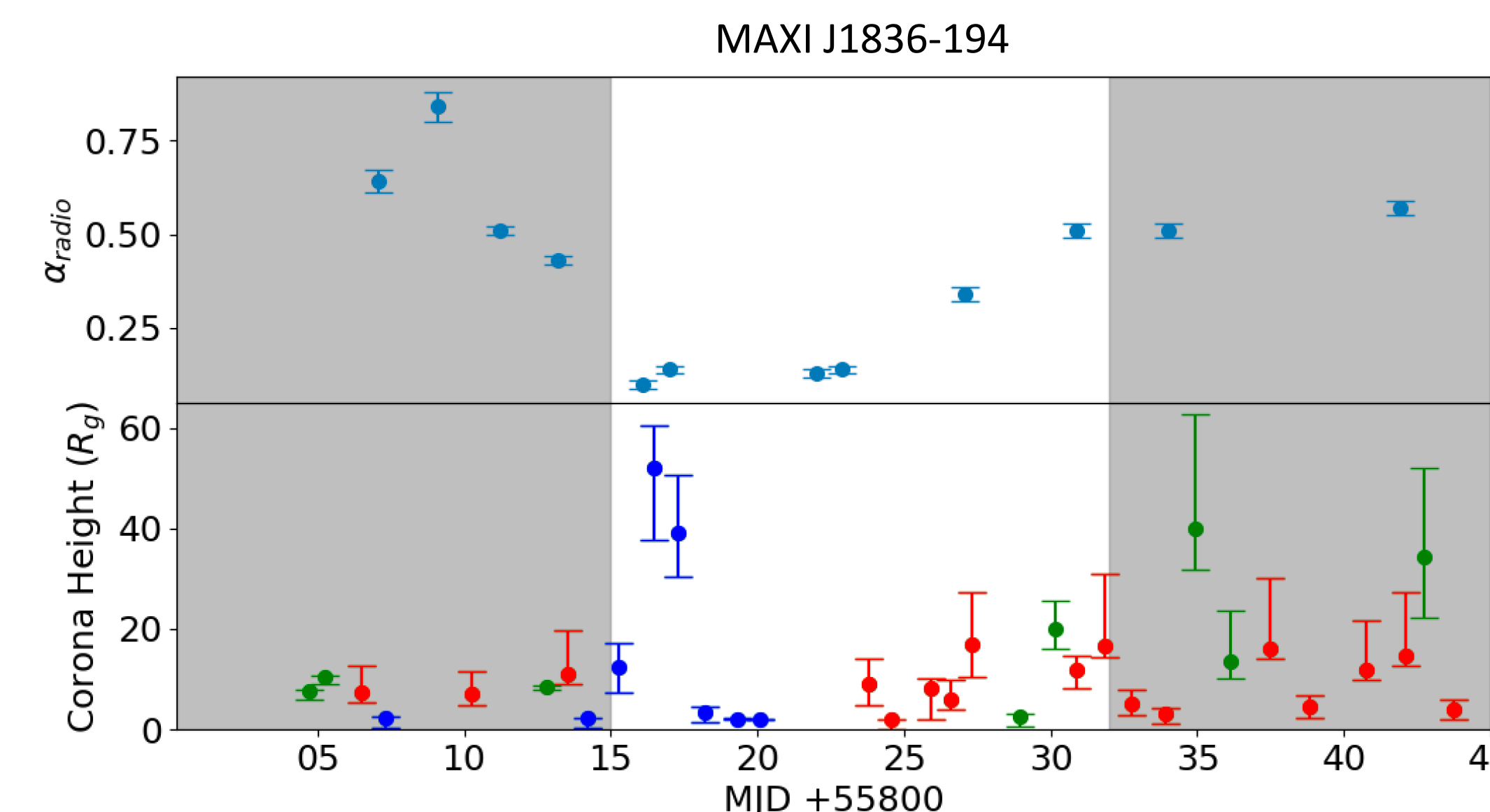


Figure 2. MAXI J1836-194 X-ray corona heights and radio spectral indices.

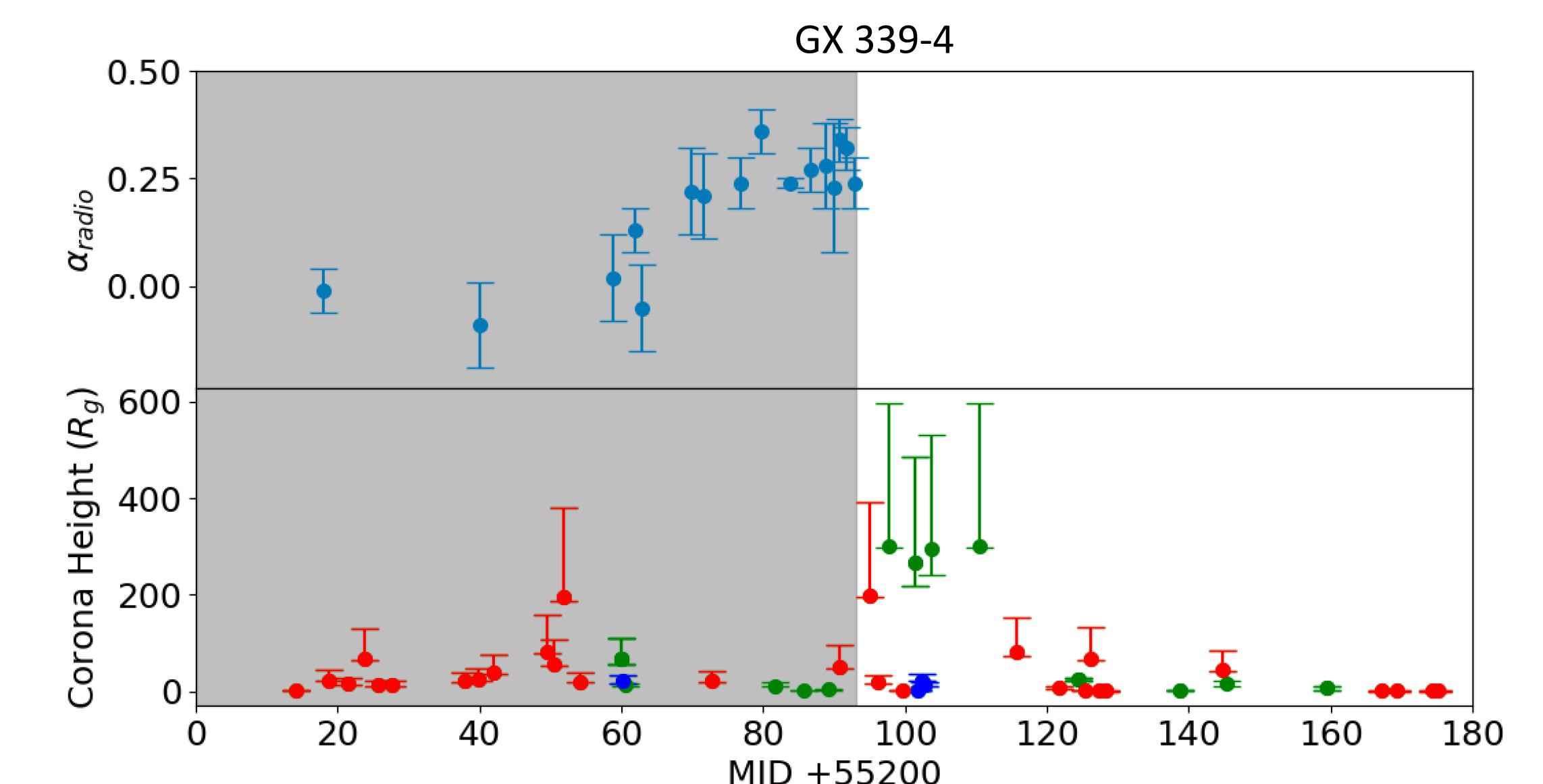


Figure 3. GX 339-4 X-ray corona heights and radio spectral indices.

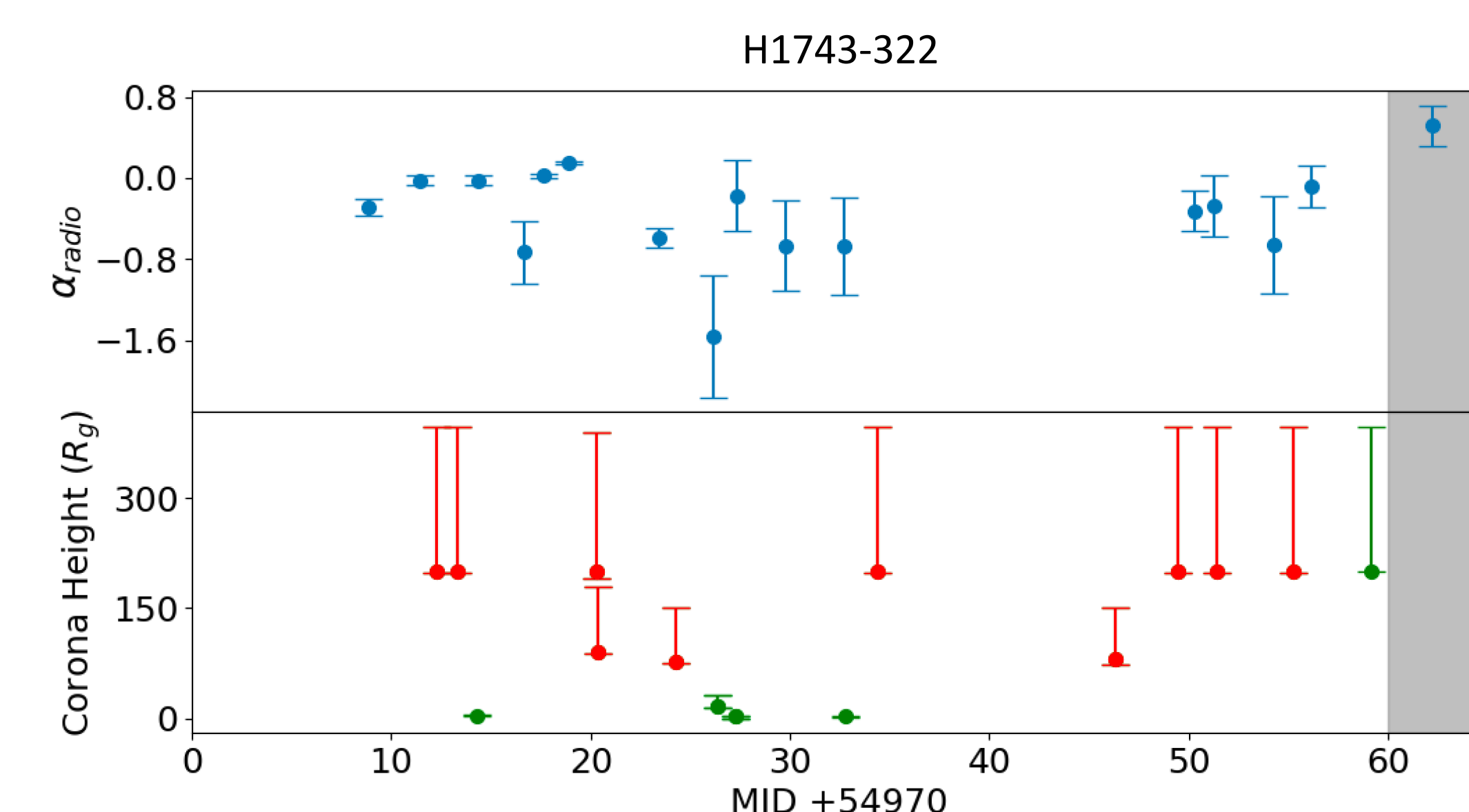


Figure 4. H1743-322 X-ray corona heights and radio spectral indices.

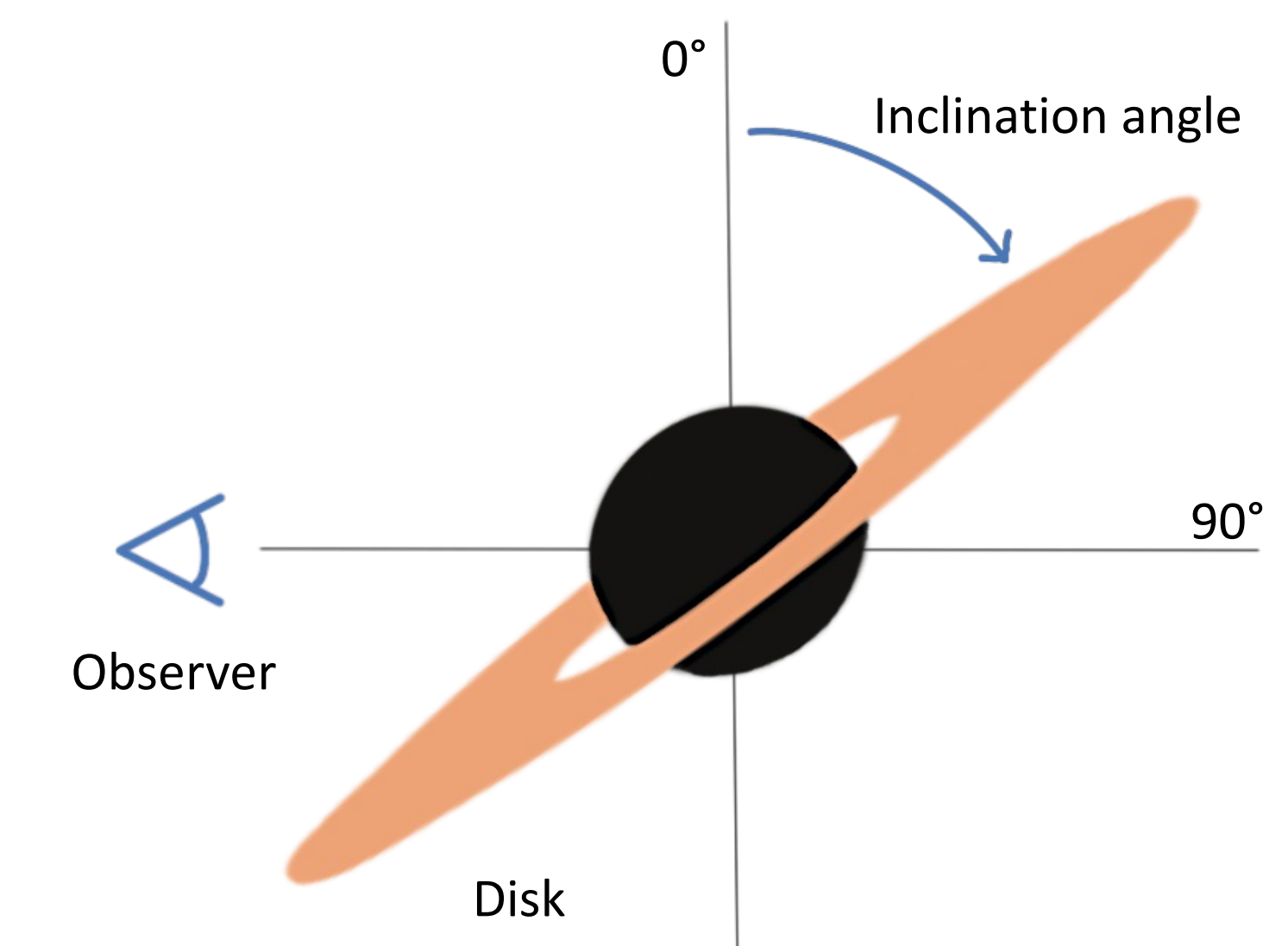


Figure 5. Targets are best observed at lower disk inclinations, otherwise disk reflection is not well accounted for.

Discussion

MAXI J1836-194

- The corresponding drop in radio spectral index and jump in coronal height suggests a physical connection.
- This outburst was “failed” [1] and the compact jet did not become transient, but it still provides valuable information.

H1743-322

- Results are likely due to a high angle of inclination ($\sim 75^\circ$) impacting detection of disk reflection (see Figure 5).

GX 339-4

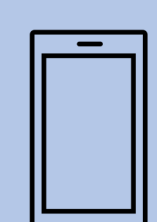
- The abrupt increase in coronal height might be observed right around the time the accretion disk starts to dominate.
- No radio data is available to definitively confirm that this increase in the coronal height corresponds to the transition to the transient jet.

Conclusion

The analysis of two out of our three studied black holes suggests that the coronal height increases rapidly right around the time that the jet changes its nature from compact to transient. Further research is required to determine whether this is consistent across all sources and whether the jet change is leading or trailing the changes in the corona.

Contact

Charlotte Johnson
 University of South Carolina Honors College
 Email: cej21@email.sc.edu



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