Analyzing Straylight X-ray Binary Candidates with NuSTAR

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INTRODUCTION

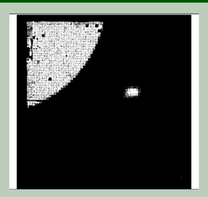


Figure 1: An example straylight observation

NuSTAR's design includes a deploy-able mast that is "open" to the space around the craft. This means that stray photons from sources that lie 1–4° away from the line of sight can fall on to the detectors of the scope, without going through the optics (fig 3). In the 8 years since its launch, NuSTAR has made many thousands of these serendipitous straylight observations. These accidental data potentially contain a wealth of information that may be used in research. This work serves as a proof of concept for the efficacy of straylight research, and is two-fold. First, we loosely recreate the results of a Homan et al. 2018 paper of source GX5-1. Second, we analyze source GX17+2. These sources are both neutron star x-ray binaries and z-track sources. Analyses of both sources used similar methods.

METHODS

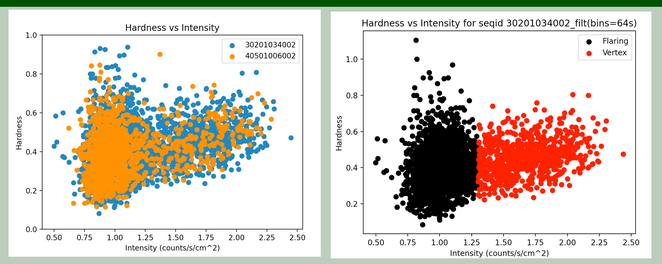
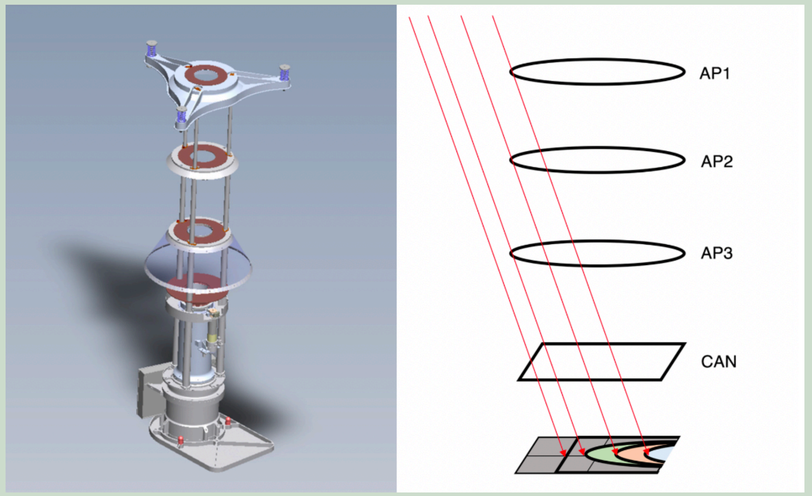


Figure 2: Example HIDs from GX17+2. One (left) shows both observational data sets while the other (right) shows a single data set split between the two different z-track branches

For each of our two sources, we began by searching through known straylight observations. We pulled out several that had good coverage on the detectors (fig.1) and decent exposure times. We were then able to use the python code written for this project to pull out light curve and spectral data. From here, we plotted the data sets on a hardness-intensity diagram (fig.2) to get a sense of what part(s) of the z-track had been observed (For GX17+2, we find a flaring branch and vertex). The data were split by z-track branch, and a spectrum was made for the each. From here, we were able to create models for the spectra. For source GX5-1, we created a very simple model to confirm the results of Homan et al. 2018, and were satisfied enough to end our proof of concept analysis there. For GX17+2, we fit the data with a flavor of the relxill model that is appropriate for NSs. We were able to create models for both of our observations in the vertex part of the z-track with reasonable parameter values.



Diagrams created by the NuSTAR Group

Figure 3: an illustration of a part of NuSTAR's open mast (left) and a diagram showing how straylight observations occur (right)

METHODS CONT.

RESULTS

GX5-1: our primary result was that there was no iron-line reflection feature visible in the source's spectra. Without an iron line to analyze, there was little more to do that had not already been done in Homan et al 2018.

RESULTS CONT.

GX17+2: By fitting the spectrum (with the iron reflection line) to a relxillNS model, we were able to determine several physical characteristics of this source and compared them with the values found in the literature.

Parameter	Our value	Ludlam et al. 2017
Inclination	37.1 ± 4.4°	35.1 (+0.2, -.6) °
Disk Temp.	1.5 ± 0.2 keV	1.93 ± .04 keV
Inner Radius	12.4-2121.7 km	12.4 ± 2.5 km

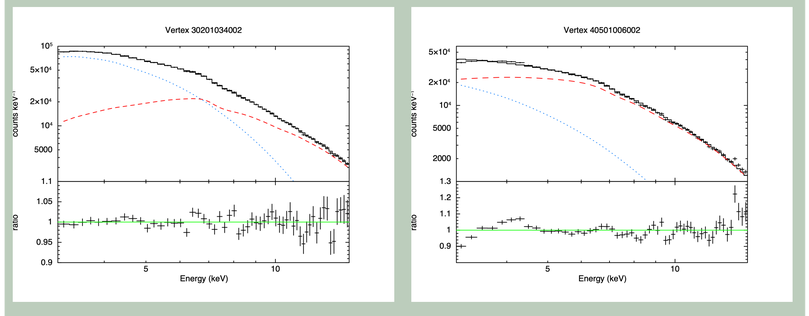


Figure 4: Vertex spectra and final models for GX17+2

DISCUSSION AND CONCLUSION

The work done this summer clearly shows that straylight data from NuSTAR can absolutely be used for astrophysical research. By loosely recreating the results of Homan et al. 2018 with GX5-1, we show that the data processing code created for straylight data works as expected and yields similar spectra to those achieved with normal observations. In our study of GX17+2, we show that further analysis of these spectra is also possible, working with the same models currently used in binary system research, and found values consistent with those in the literature.

REFERENCES

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