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# Separating Near-Object Spectra From Chandra Grating Observations

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## Background

A vast amount of knowledge about stars comes from observing their spectra in the x-ray wavelengths; however, when there are multiple stars in close proximity, such as in binary systems or clusters, reading these spectra becomes ineffective because they overlap one another when read onto ccds in telescopes. This research aims to look at the CEN 1A and CEN 1B binary system in the M17 cluster and attempt to separate their spectra. The stars are observed by the HETG instrument on the Chandra space telescope, which detects in the x-ray wavelengths. This separation was done by simulating the binary stars using the MARX program developed at MIT, which was designed to simulate data specifically for the Chandra telescope, and allows for the creation of ds9 files to compare the simulation visually with the actual stars. This research aims at creating a simulation in MARX for the M17 system in order to observe how much each star affects the spectrum of the other. This research is necessary because the HETG grating is open, and will produce a spectrum for every source in the field of view on the same detector.

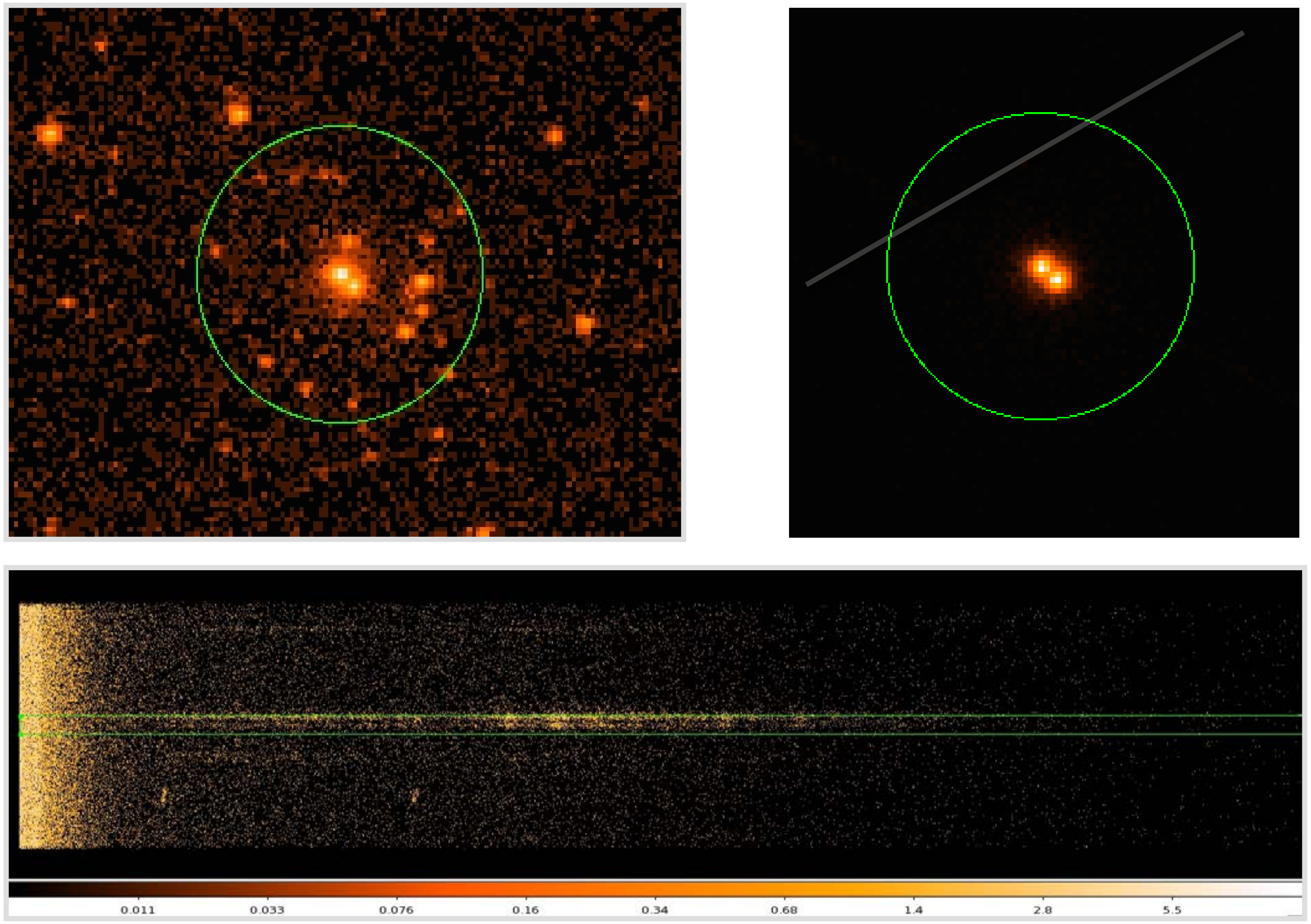


Figure 1 (top-left): circled in the center is the Cluster with CEN 1B at the top to the left and CEN 1A at the bottom right. (top-right): This shows the MARX simulation image of two stars in the same positions as CEN 1A and 1B. The line represents the cross-dispersion axis. (bottom): the spectra for the two stars are in the center with CEN 1B on the top and CEN 1A on the bottom. The box shows the area where the majority of the photons for CEN 1A will be located. The box outline is clearly overlapping with the upper spectrum.

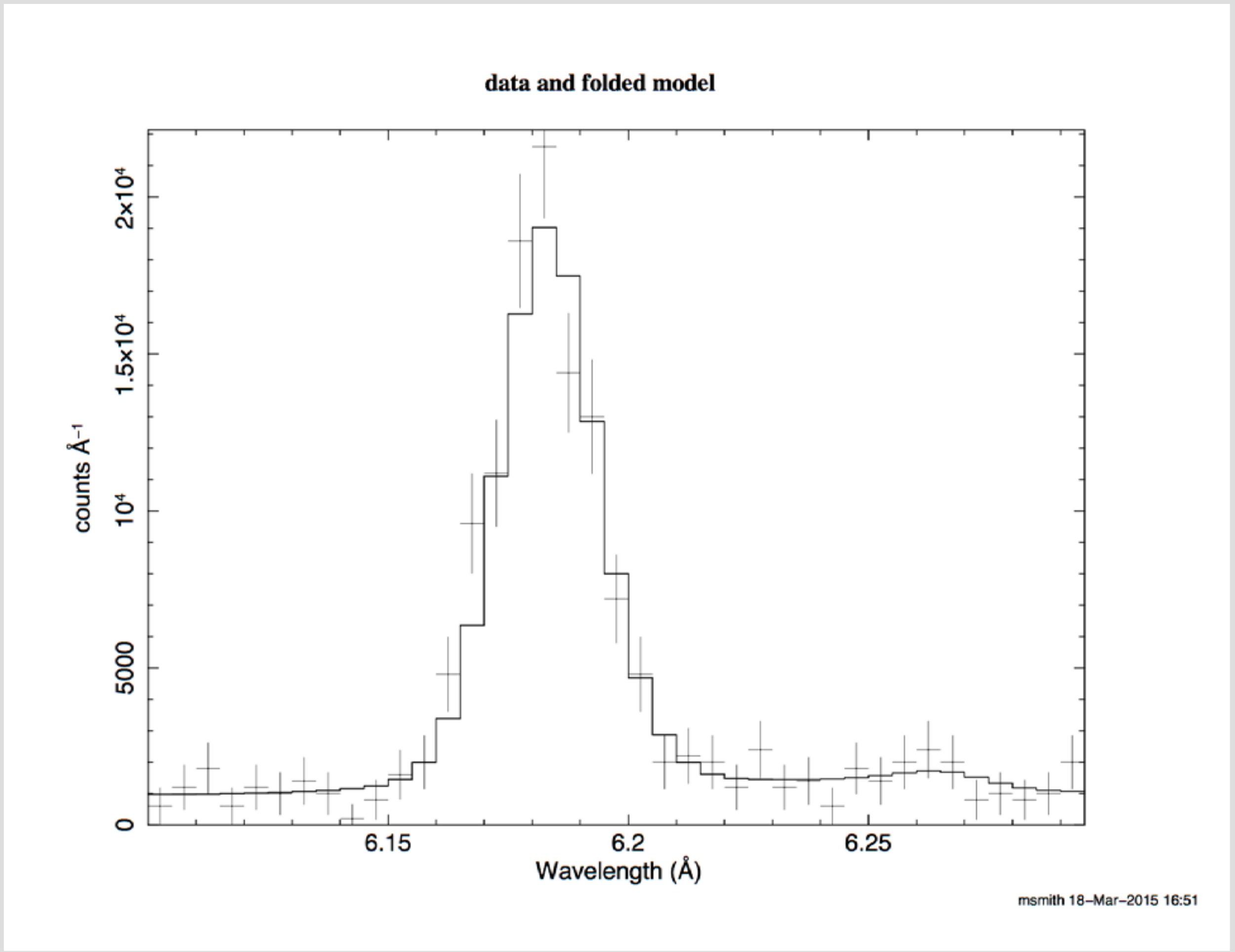
## Method

The data from Chandra are processed through scripts in the CIAO codes that allows for calibrating, destreaking and removing excess photons from the data. The final image is observed in SAO imager ds9, where it will be compared to the simulation data created using the MARX program.

To create the simulated data in Marx, two 1 keV stars are "inserted" into the same positions as CEN 1A and 1B in the observations from Chandra. The data is processed through the same CIAO codes as the observed data. The data from Marx is then graphed in the modeling program Xspec. The figures below show the negative and positive MEG grating arms zoomed to show the silicon xiii spectral line. Figure 2 shows the negative first order spectrum where CEN 1A is shown having shorter wavelengths, while figure 3 shows the positive first order spectrum where CEN 1A has longer wavelengths than expected.

## Results

Left-side




Right-side

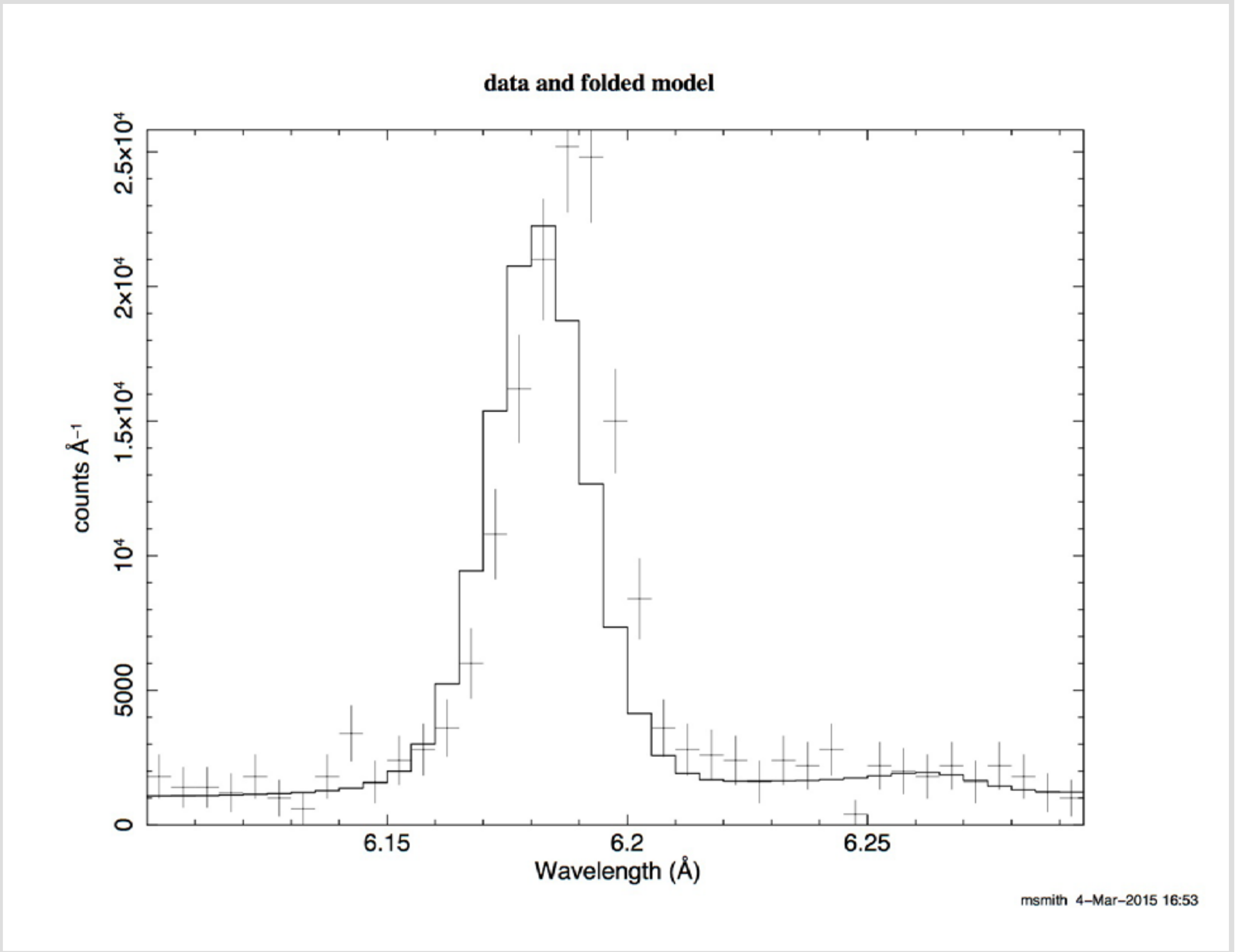



Figure 2 shows the negative (left) first order of the spectrum for the CEN 1A and 1B system,while Figure 3 shows the positive MEG grating arm, where the solid line is the observed counts from just CEN 1B, and the cross-dotted line represents the total photon counts with both stars contributing.

As can be seen in Figure 3, the peak of the spectrum for the binary simulation is shifted to the right of the peak for the single star. During the spectral extraction, CIAO is set to use the position of CEN 1B as the origin for the dispersion coordinates, and due to 1A and 1B's slight misalignment on the cross-dispersion axis, CEN 1A's photons are read to have a slightly longer wavelength on the positive MEG grating arm. Conversely, in figure 2 the photons emitted by CEN 1A are read as having a slightly shorter wavelength than it actually emits, thus increased photon counts at the lower wavelengths. Most of the small differences between the negative and positive arms are due to the difference in pixels that MARX is simulating, since MARX is meant to simulate the MEG gratings, and the gratings are not perfectly identical on the Chandra telescope.

**Due to location bias based on CEN 1B being the origin of the observations, CEN 1A will be represented as shorter or longer wavelengths depending on if the negative or positive spectrum is observed, respectively.**

## What's Next

With the two major sources of interference observed, the next step will be to simulate the interference from the bright surrounding stars near the binary system and along the dispersion axis of the spectrum. After the M17 system additions, this simulation method will be applied to the archived Chandra observations of the Orion Nebula Cluster, which is a close star forming region. This will work to strengthen the methods used in M17, while seeing for how many stars the method is able to extract individual spectra.