HETGS

Michael Nowak, for the HETGS Team

The High Energy Transmission Gratings Spectrometer (HETGS) continues to perform as expected. There have been no calibration changes specific to the HETGS, although the time-dependent contamination, leading to a loss of effective area at low energies, continues to affect HETGS observations. Observations with the HETGS in fact have been crucial in characterizing the composition (via studies of contaminant absorption edges), time-dependence, and spatial dependence of the contaminant. For the latter studies, "big dither" observations of Mkn 421 have helped to map out the depth of the contaminant relative to the position of the spectrum on the detectors.

HETGS also has been used to characterize cross-calibration with other X-ray satellites. In June 2014, simultaneous *Chandra*-HETGS, *Swift*, and *XMM-Newton* observations were performed on the X-ray binary Cyg X-3. Fig. 1 shows the Fe line region from this observation. Not only are these data useful for cross-calibrating effective areas, but the high-precision with which HETGS can measure line wavelengths can be used to gauge detector gain corrections in the other two satellites. Details of cross-calibration studies involving HETGS can be found on the web pages of the International Astronomical Consortium for High Energy Calibration (IACHEC): http://web.mit.edu/iachec.

As briefly discussed in the 2014 Newsletter, the HETGS calibration team has recently completed a study of the effect of Continuous Clocking (CC) Mode on gratings spectra. The basic conclusion was that this mode is more complicated to analyze not primarily due to calibration uncertainties, but rather due to the loss of one spatial dimension. Specifically, the collapse of spatial/spectral features, e.g., dust scattering halos which are often associated with bright X-ray binaries (a frequent target of HETGS CC-mode observations), and the overlap of dispersed HEG and MEG spectra, necessitate more sophisticated analyses. Analysis strategies and recommendations for instrumental setups can be found in the document describing HETGS CC-mode observations: http://cxc.harvard.edu/cal/Acis/Cal_prods/ccmode/ccmode_final_doc03.pdf.

In the past year, two new tools designed to aid with gratings analysis were released with CIAO Scripts Package v4.6.7. `combine_grating_spectra` allows users to combine spectra from positive and negative grating orders and co-add spectra across multiple observations. The script can be used with either Type I (i.e., one spectrum per file) or Type II (i.e., multiple spectra per file) PHA files. The script also will automatically combine response and background files. `tgsplit` is a tool that will convert Type II PHA source and background spectra into Type I PHA files, and then associate the proper response files with the newly generated Type I files.

Observations and Archive

In 2014, 53 observations were performed with HETGS (including guest observer, guaranteed time, and calibration observations), on 26 different objects, for a total integration time of slightly longer than 3 Msec. As these observations become publicly available, they are automatically added to the Transmission Gratings Catalog (TGCat): http://tgcat.mit.edu. The scripts used to generate these results are available to all users from the catalog website. In 2014, 51 extractions of HETGS observations, representing 22 different objects and an integration time of 3.1 Msec, were added to the catalog.

TGCat archives an automated analysis of what is typically the aim point object of the observation. However, a number of the observations contain multiple sources (e.g., when viewing a stellar cluster), or other serendipitous sources. The TGCat web front

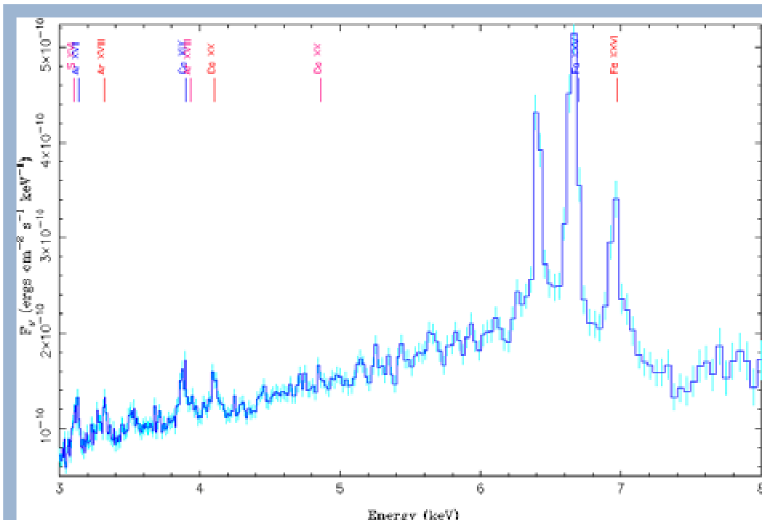

Fig. 1 — Chandra-HETGS spectra of the X-ray binary Cyg X-3, taken from the calibration observation that was performed simultaneously with XMM-Newton and Swift. The Fe line region is highlighted. The precision with which Chandra-HETGS measures the energies of these lines allows more accurate gain corrections of the other two instruments. Additionally, effective areas of all three instruments will be compared with these observations.

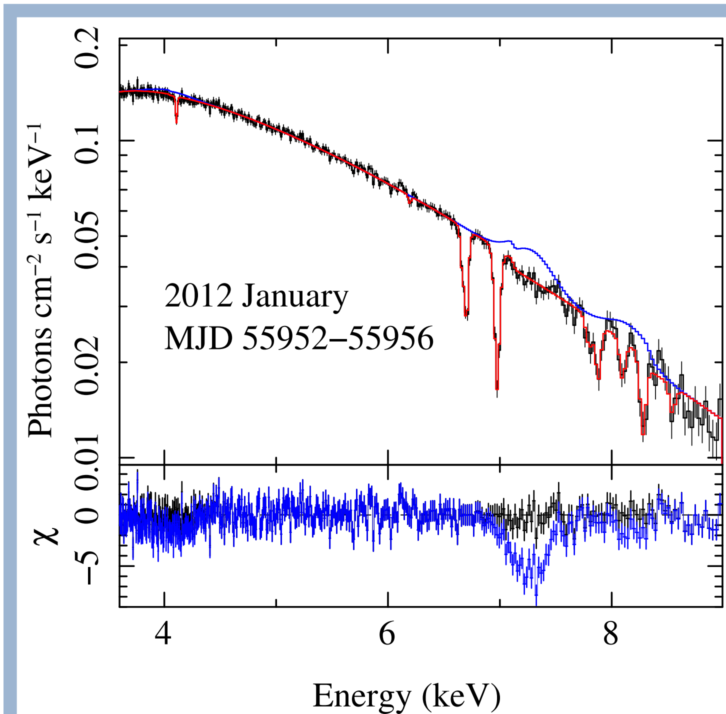

*Fig. 2 — Chandra-HETGS spectrum of 4U 1630–47. The red line/black residuals show the best fit model, including a blue-shifted (~ 200–500 km s^{-1}), absorbing wind (Neilsen et al. 2014). The blue line/blue residuals show the model including relativistically blue-shifted (0.66*c*) emission lines as observed, via XMM-Newton studies, from a brighter and slightly harder spectral state later in the outburst (Díaz Trigo et al. 2013).*

page contains a form for users to request extraction and archiving of any such sources.

Selected Scientific Highlights

The use of HETGS has allowed *Chandra* to observe the brightest X-ray sources in the sky (with the exception of the Sun!). These are typically X-ray binaries, which have become prime targets for the HETGS. High spectral resolution HETGS observations have revealed evidence of outflowing accretion disk winds, with observations of individual objects hinting at a dichotomy between spectral states that show steady compact, flat spectrum radio jets and those that show outflowing winds. This has led to the hypothesis that the there is a "wind-jet connection" in X-ray binaries (Miller et al. 2008, Neilsen & Lee 2009). As population studies utilizing HETGS (as well as *XMM-Newton*, *Suzaku*, and NuSTAR) have progressed, this connection is becoming more firm (Ponti et al. 2012). In black hole candidate (BHC) systems, (typically) lower luminosity, spectrally hard sources exhibit evidence of a steady compact radio jet, while brighter spectrally soft sources exhibit a wind (if the system is viewed at high inclination) with any radio emission being optically thin and transient.

Recent HETGS (Neilsen et al. 2014) studies of a bright soft state of the BHC 4U 1630-47 examined evidence for the presence of relativistically blue-shifted (0.66*c*) emission from a baryonic jet, as observed with *XMM-Newton* CCD spectra. HETGS placed strong upper limits on the presence of any such emission, and instead found the more usual blue-shifted absorbing wind (Fig. 2). The HETGS observations, however, occurred during an earlier softer and fainter portion of the outburst.

In Fig. 3, we show an HETGS observation of the BHC MAXI J1305-704 (Miller et al. 2014). Here rather than detecting a blue-shifted wind, tentative evidence is instead found for a red-shifted "failed wind." Owing to the large off-axis angle at which these observations occurred, simulations with the MARX package (http://space.mit.edu/ASC/MARX) were crucial in the analysis.

Although the "wind-jet connection" is becoming more established in X-ray binary studies, *Chandra*-HETGS observations are revealing an even richer and more complex phenomenology than originally thought.

References

Díaz-Trigo, M., et al. 2013, Nature, 504, 260.

Miller, J., et al. 2008, ApJ, 680, 1359.

Miller, J., et al. 2014, ApJ, 788, 53.

Neilsen, J. & Lee, J. C. 2009, Nature, 458, 481.

Neilsen, J., et al. 2014, ApJ, 784, L5.

Ponti, G., et al. 2012, MNRAS, 422, L11.

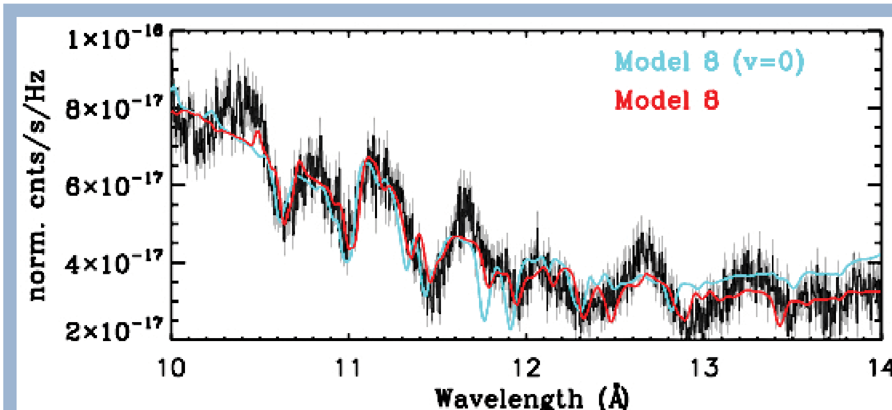

Fig. 3 — Chandra-HETGS spectrum of MAXI J1305– 704, with a redshifted (~ 14,000 km s^{-1}) absorber component (red line; Miller et al. 2014). The blue line shows the same model with the absorbing wind velocity set to zero.