[3.06] Chandra XV
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SPECTRUM ULTIMUM CAPELLAE

XV Years of Chandra Observations of Capella

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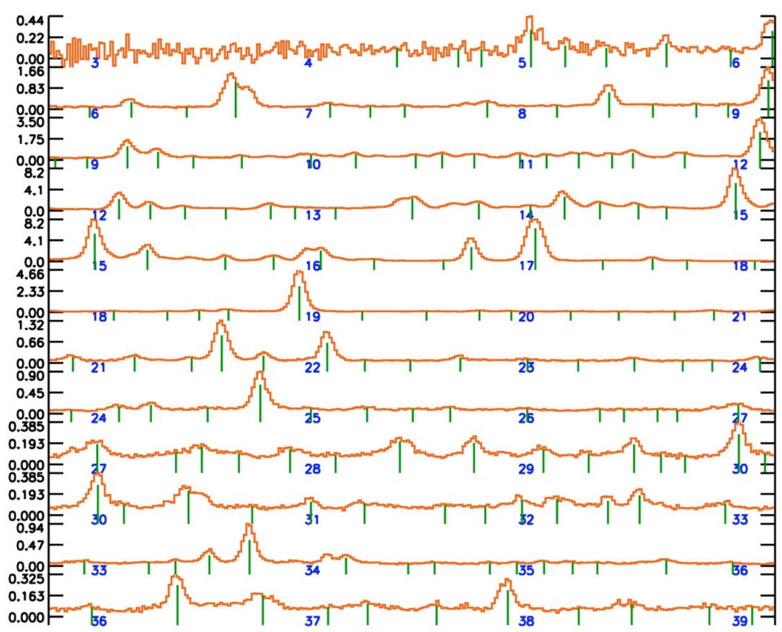
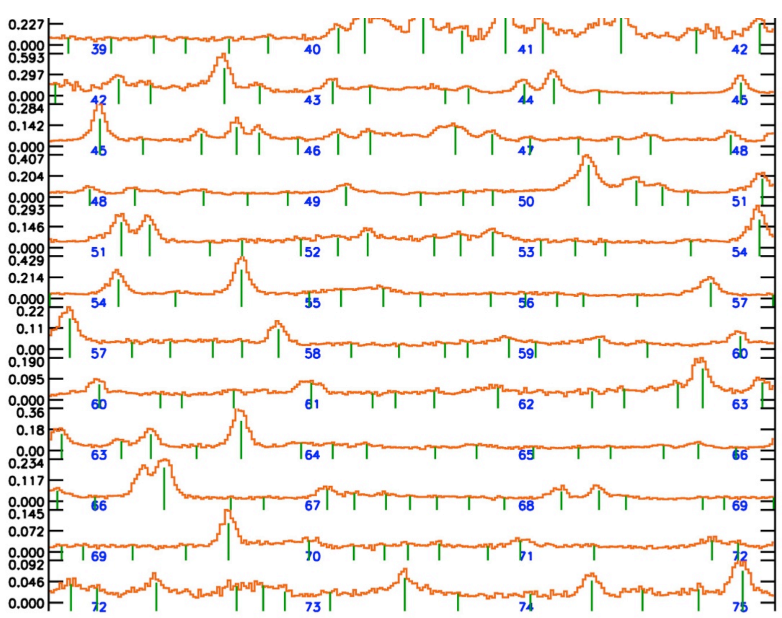
Capella Datasets

ObsID	Detector/ Grating	Exposure [ks]
01099	ACIS-S/HETG	14.5709
01235	ACIS-S/HETG	14.5701
01100	ACIS-S/HETG	14.5707
01236	ACIS-S/HETG	14.5704
01101	ACIS-S/HETG	14.5702
01237	ACIS-S/HETG	14.5707
01199	ACIS-S/HETG	2.06614
62435	HRC-S/LETG	32.3781
01167	HRC-S/LETG	15.1418
01244	HRC-S/LETG	12.1179
62410	HRC-S/LETG	11.227
01246	HRC-S/LETG	14.6014
62422	HRC-S/LETG	11.2918
62423	HRC-S/LETG	14.559
01103	ACIS-S/HETG	40.516
01318	ACIS-S/HETG	26.6976
01420	HRC-S/LETG	29.9591
01248	HRC-S/LETG	84.5969
00055	ACIS-S/LETG	53.4769
01225	ACIS-S/LETG	6.15138
00057	ACIS-S/HETG	28.8354
00058	HRC-S/LETG	33.9006
01010	ACIS-S/HETG	29.538
01009	HRC-S/LETG	26.8346
02583	ACIS-S/HETG	27.6034
02582	HRC-S/LETG	28.6583
03479	HRC-S/LETG	27.4494
03674	ACIS-S/HETG	28.6767
03675	HRC-S/LETG	26.9638
05040	ACIS-S/HETG	28.6718
05041	HRC-S/LETG	28.6694
05955	ACIS-S/HETG	28.6767
05956	HRC-S/LETG	29.9275
06165	HRC-S/LETG	28.9364
06471	ACIS-S/HETG	29.5587
06472	HRC-S/LETG	29.9096
08319	ACIS-S/LETG	59.1465
09638	ACIS-S/HETG	31.0306
10600	HRC-S/LETG	29.5802
10599	ACIS-S/HETG	29.181
11931	ACIS-S/HETG	29.5524
11932	HRC-S/LETG	30.284
13090	HRC-S/LETG	29.8949
13089	ACIS-S/HETG	29.5622
14240	HRC-S/LETG	29.9317
14239	ACIS-S/HETG	29.5304
16418	ACIS-S/HETG	29.5424

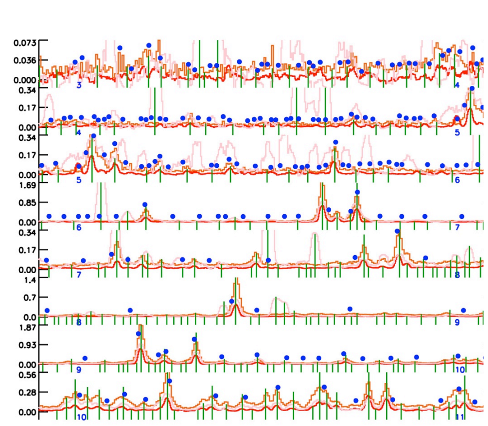
Capella is the strongest coronal line source accessible to Chandra. It has been cumulatively observed with gratings for over 1.2 Msec (see Table at left). The accumulated spectrum represents astrophysical ground truth for atomic physics calculations that is unprecedented in quality. We have analyzed both individual observations as well as the co-added spectra with a newly developed spectral line detection method (HAARDETECT). We present a preliminary list of detectable lines and their locations, spanning two orders of magnitude in photon energy. We plan to use these lists to compare line emissivity databases CHIANTI and ATOMDB. The full line lists and comparisons will be made available at the Dataverse at http://dx.doi.org/10.7910/DVN/27084

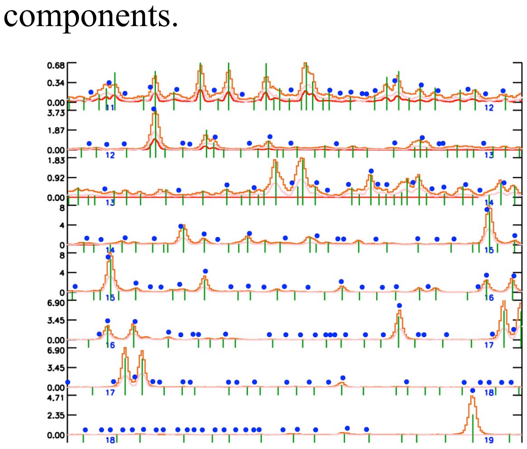




FIGURES: Illustration of detected lines. Coadded flux spectra (1st order HRC-S/LETG at right, and 1st, 2nd, and 3rd order ACIS-S/MEG at bottom right) and line detections.

SUMMARY: The dataset consists of 22 ACIS-S/HETG (536.6 ksec), 21 HRC-S/LETG (606.8 ks), and 3 ACIS-S/LETG observations (118.8 ks). We analyze ±3,±2,±1 orders for ACIS spectra, and ±1 orders for HRC spectra. We carry out line detections for individual spectra, for combined +ve and –ve orders, and for the full coadded spectra for each configuration. We merge detections by percolating line locations that are within ±0.01Å. We find 409, 504, 512, 628 lines in HEG, MEG, ACIS/LEG and HRC/LEG spectra for ~1300 unique detections. Detections from coadded spectra are shown as green bars for HRC-S/LETG (above) and ACIS-S/MEG (right; orders 1,2,3 as orange,red,pink). For comparison, lines found in individual observations are shown as blue dots (right). The number of false detections are suppressed with coadded spectra. Evaluation of apparent false detections found in multiple ObsIDs are ongoing.





HAARDETECT

Automated line detection in X-ray gratings spectra is a difficult problem, because of the large numbers of weak lines at low counts, contamination due to nearby lines or wings from strong lines, as well as background, large variations in dynamic range (by factors >1000) over small wavelength ranges, and the line widths usually being comparable to the bin widths.

We have developed a new Haar-wavelet based algorithm to detect spectral lines. We use the symmetric Haar wavelet, which has a central positive step, flanked by negative steps spanning the same width, but at half the depth. That is,

$$H(x,w) = -1/4w,\ 0.5w < |x| < 1.5w$$
$$= +1/2w,\ x \in [-0.5,+0.5]$$

Thus, convolution of a flat spectrum with the Haar wavelet yields 0.

The algorithm computes the wavelet coefficients as a scan statistic at different scales (less the contribution from the background), and identifies the local maxima over a running window that is equal to or larger than the largest scale used. Counts in bins adjacent to the local minima are then combined and tested for non-negative S/N. The locations of the lines are also adjusted by recomputing them as counts-weighted averages. These latter calculations minimize the errors in location due to counts fluctuations.

We use scales {2,3,4} for HETG spectra, and {4,6,8} for LETG spectra. Optimally, the scales should be set based on the width of the line spread function. Other enhancements to the algorithm, designed to minimize false positives, such as using simulations to set thresholds on wavelet coefficients (as is done with the 2D spatial detect algorithm WAVDETECT), and using formal line profile fitting to further improve line locations are also being developed. The latter is necessary to handle unresolved line complexes which are not detected as distinct components.

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