We analyze a decade of Chandra/HRC grating and imaging observations of the active binary Capella to characterize its X-ray variability at various timescales. Examining 205 ks of HRC-I imaging data taken over a time period of 14 months (Dec 2005 to Jan 2007), we find broadband variability at the 2-7% level at short timescales (~5 ks). At timescales of months to years, we see variations of up to ~10% in the HRC-I fluxes. Twelve HRC-S/LETG observations taken over the ten year period since launch, for a total of 408 ks, indicate that the overall flux was steady until late 2004 but has increased by roughly 50% since that time.

In addition to monitoring broadband flux, we use the HRC-S/LETG observations to analyze the line emission in detail for several lines. After correcting for the overall flux changes, we determine how the line fluxes vary, allowing us to characterize the variability at different temperatures in the corona.

Variability is present at all temperatures, and we find that the high temperature plasma is more strongly variable than the low temperature plasma. We explore this variability for spectral lines of different elements at different temperatures. The emission measure structure of Capella undergoes changes more extensive than hitherto suspected.

**HRC–S/LETG:**

**Long–term broadband and line flux variability**

- Observations listed in Table 1
- Overall luminosity of Capella rapidly increased in late 2004, rising by ~50% (Figure 1)
- We examine line fluxes for 29 lines, before and after correcting for the broadband flux changes. Fluxes vs time are shown for eight lines in Figure 2.
- After correcting for broadband luminosity changes, we find line flux variability in excess of statistical expectations (Figure 3). We find strong evidence for variability at many temperatures, with dominant contributions between $T_{\text{eff}}$ = 3.3–6.5.
- We also calculate the fractional variability for the corrected line fluxes (Figure 4). Both cool and hot lines show similar variability.
- There appears to be very little variability at $T_{\text{eff}}$ < 6.8.

**Figure 1** Capella broadband X-ray intensity; smooth curve passes through points corrected by QE and counts correction (time since launch around 150 months). Chandra X-ray Observatory.

**Figure 2** Line fluxes versus time for FeIX (171.075 Å, $T_{\text{eff}}$ = 1.9), FeX (195.853 Å, $T_{\text{eff}}$ = 3.3), SiIV (140.214 Å, $T_{\text{eff}}$ = 4.5), SiIII (120.820 Å, $T_{\text{eff}}$ = 6.9), SiII (191.998 Å, $T_{\text{eff}}$ = 9.2), and F VIII (172.562 Å, $T_{\text{eff}}$ = 14.1). The data from these five lines are shown in Figure 1. Plot axes shown for each element correspond to the theoretical measure, subtracting background, convolved with the appropriate ARF and sampling. The blue squares show the line fluxes corrected by the appropriate ARF and sampling. The raw data points show the line fluxes corrected for flux variations in the week before the XMM-Newton observations.

**Figure 3** Excess variability in Capella line fluxes at different temperatures. This plot shows the relative increases ($\delta C_t / C_t$) calculated from the line fluxes corrected for zeroeth order variability, versus coronal temperature. We calculate $\delta C_t = C_t - \langle C_t \rangle$, where $\langle \rangle$ is the mean of observations, $C_t$ is the line flux corrected by zeroeth order variability, and $C_t$ is the mean line flux. The black line shows the limit of the zeroeth order variability, versus time.

**Figure 4** Fractional variability in Capella line fluxes at different temperatures. The line fluxes corrected for broadband luminosity changes, at different temperatures. We also plot fractional variability, $\delta f_t / f$, where $f_t$ is the fractional variability of the line fluxes and $f$ is the mean. Both line and time at $T_{\text{eff}}$ = 3.9 and 5.5 show the strongest terrestrial variability.

**Figure 5** Combined light curve of Capella, spanning 1,000 ks. The flux histogram shows the increase rate for a time binning of 100 s, and gives the count rate in the count rate for a binning of 500 s (green histogram). The data from between observations are excluded, and statistically excluded (black triangles) if less than 50 ks of data were present. The data from the final 100 s are outside the excluded region and are shown as the red line. The data are corrected for zeroeth order variability, versus temperature. The count rate and exposure time of the observation. The values expected for Poisson fluctuations are shown as the horizontal dashed line. The overdispersion in the light curve in each Capella ObsID. The overdispersion measure, $\sigma_{\text{over}} = \sqrt{\chi^2} - 1$, is shown as the blue band whose width corresponds to the $\pm 3\sigma_{\text{over}}$ band for Capella) is shown as the pale blue band whose width corresponds to the $\pm 3\sigma_{\text{over}}$ band for Capella.

**Figure 6** Overdispersion in the light curve in each Capella ObsID. The overdispersion measure, $\sigma_{\text{over}} = \sqrt{\chi^2} - 1$, is shown as the blue band whose width corresponds to the $\pm 3\sigma_{\text{over}}$ band for Capella.

**References**