THE TRANSITION REGIONS OF CAPELLA

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ABSTRACT We report on an extensive set of observations of Capella obtained with the GHRS on HST at orbital phase 0.26. The data set consisting of low, moderate, and high resolution spectra, allows us to separate the contributions of each star to many of the emission lines and to measure line centroid redshifts. We estimate the electron density in the transition region of the hotter star and construct an emission measure distribution.

The low resolution G140L spectra of the Capella system (G0 III + G8 III), covering the spectral interval 1165 – 1710 Å, show weak spectral lines not seen in the coadded IUE spectra. The fluxes of strong lines agree well with those in IUE spectra, but the fluxes of weaker lines differ due to blends and/or difficulties in determining the continuum level.

The excellent quality moderate resolution G140M, G160M, and G200M spectra of chromospheric and transition region lines require several Gaussian components for accurate fits. Figure 1 shows examples of the moderate resolution spectra (histograms), the individual Gaussian components (thin lines), the sum of these components (thick solid lines), and the convolution of this sum with the instrumental profile (thick dotted lines). The O I 1302, 1305, and 1306 Å lines can each be fit with two components, one representing the hotter star and the other the cooler star, with the cooler star providing 69% of the total flux. The O I 1302.2 Å line is also fit with an ISM absorption feature and the S I 1302.9 Å line in its red wing.

The Si IV and C IV lines require Gaussian components for each star and, in addition, show broad wings which require a very broad component (FWHM \(\approx 340 \text{ km s}^{-1}\)), which also must be from the hotter star, based on the measured centroid velocities. Broad components of transition region lines are also seen in the spectra of the dM0e star AU Mic and are interpreted as evidence for high-speed plasma motions produced by magnetic field recombination (Linsky and Wood 1994). Figure 1 shows these broad components for the Si IV and C IV lines.
lines in addition to Gaussian fits to the O IV] and S IV] lines near 1400 Å. The multi-Gaussian analysis of the Si IV and C IV lines indicates that 92% of the flux in these transition lines comes from the hotter star. The He II 1640.4 Å line shows a broad feature, indicating collisional excitation primarily from the hotter star, and a weak, very narrow feature that we interpret as due to radiative recombination following photoionization on the cooler star.

In our multi-Gaussian fits we fix the centroid radial velocity of the Gaussian representing the cooler star at the photospheric radial velocity but do not constrain the radial velocities of the other components. We find that the hotter star’s O I emission lines are redshifted by +8.6 km s\(^{-1}\) relative to the photosphere, while the Si IV and C IV lines are redshifted by +19.5 km s\(^{-1}\). Redshift data for other stars measured with the GHRS are presented by Linsky, Wood and Andrilis (1994).

The Mg II resonance lines, which were obtained using the high resolution echelle-B grating, were each modeled with Gaussians to estimate the contribution of each star to the profile. The Mg II profiles require at least 5 Gaussian components — two emission Gaussians representing the hotter and cooler stars, two absorption Gaussians representing the central reversal for each star, and an ISM absorption feature. The position of each component was fixed to be in the rest frame of the star responsible for that component, except for the ISM component. In the Mg II lines the hotter star contributes 53% of the flux.

Measurements of the intersystem lines of C III], O III], Si III], O IV], and S IV] allow us to determine values for the transition region electron density using nine different density-sensitive line ratios. The densities derived from the different diagnostics all lie within a factor of 5 of the mean value, log n\(_e\) = 10.6. The multigaussian profile analysis allows us to separate the flux contributions of each star and to construct emission measure distributions for each star. For example, we compare the emission measure distribution of the hotter star with that for a solar active region (Judge and Brekke 1993). For the hotter star in the Capella system, the intersystem lines fall systematically below the resonance lines, and the difference increases with increasing electron temperature. This indicates that the electron density increases with electron temperature, and therefore the filling factor of material emitting the resonance lines must decrease with increasing temperature. Like the Sun, the emission measure analysis coupled with the density sensitive lines of O IV] indicates that the transition regions are highly inhomogeneous, with very fine structures emitting most of the radiation from transition region lines.

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REFERENCES

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FIGURE I  Observed emission lines of Capella (histogram), Gaussian components (thin lines), sum of Gaussian components (thick lines), and convolution of the sum (dots). Note the broad Gaussian components in (c), (d), and (e).