PRELIMINARY RESULTS FROM SPARTAN 201: 
CORONAL STREAMER OBSERVATIONS

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Abstract. The Ultraviolet Coronal Spectrometer on Spartan 201 obtained measurements of H I Ly α line profiles and O VI λ103.2/103.7 nm integrated intensities in a helmet streamer. Similar measurements were made on the solar disk to characterize the incident radiation which is the source for the resonantly scattered component of the lines. A description of the H I Ly α observations in the streamer will be presented. A more complete physical description of the observed coronal regions will become available after the analysis of additional data from coordinated observations made by visible coronagraphs and x-ray telescopes.

Key words: Coronal Streamers, Solar Wind, UV Spectroscopy

1. Introduction

A helmet streamer on the SE limb of the Sun was observed with the Spartan 201 UV and white light coronagraphs during 11 April 1993. This paper reports on some of the preliminary results from the Spartan Ultraviolet Coronagraph Spectrometer observations. The UV coronagraph on Spartan has two separate spectrometer channels. One channel is used to provide spectral profiles and total intensities of H I Ly α (121.6 nm) and the other provides total intensities of the O VI doublet at 103.2/103.7 nm. A general overview of the Spartan UV Coronal Spectrometer flight performance and all of the UV observations is discussed by Kohl, et al. (1994).

The primary goal for this investigation is to derive or constrain the basic plasma parameters of the observed streamer. These parameters include the temperature and density of electrons and hydrogen, and the bulk outflow velocity of neutral hydrogen. The behavior of the protons is expected to be coupled to the neutral hydrogen through fast charge transfer processes (Withbroe et al., 1982). Additionally, spectroscopic measurements of the O VI doublet line will be used to determine and constrain the abundance and outflow velocity of O^{5+} ions. The present discussion will focus on the results for the proton kinetic temperatures along the streamer axis.

2. H I Ly α Profiles

Figure 1 shows the locations in the region of the SE streamer where the 59 profile observations were made. The axis of the streamer is identified by the

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dashed line in the figure. During the Spartan 201 observations, the streamer was on the East limb and its base (at 1.5 $R_{\odot}$) was located at a position angle of 135° from the north heliographic pole. Spatial coverage for the profile measurements included the streamer and the surrounding coronal hole and quiet regions.

Each spectral profile was obtained from a 0.5 arcmin by 2.5 arcmin region in the corona. Profiles were obtained at heliocentric heights of 1.5, 1.8, 2.1, 2.5, 3.0, and 3.5 $R_{\odot}$ for nine out of 10 radial scans of the Spartan UV spectrometer field of view. Nominal dwell times for the observations are 1.0, 1.0, 1.5, 3.0, 4.5, and 8.5 minutes for the heights indicated for the nine scans. The scan without an observation at $r = 3.5R_{\odot}$ has dwell times that are twice as long as those for the other scans.

Examples of the quality of the observed profiles are shown in Figures 2a – 2c. The profiles are sampled at 0.025 nm intervals and are plotted for the 0.4 nm band centered at 121.6 nm. The relative uncertainty in the peak is roughly 3 % (1 $\sigma$) for all profiles. A prominent feature of these profiles is that the peak intensity has been enhanced or reduced by the addition or subtraction of radiation by neutral hydrogen in the geocorona above the altitude of the Spartan orbit. This spectral feature is broader than the actual geocoronal line because of broadening by the Spartan Ly $\alpha$ spectrometer instrument profile which is 0.027 nm (FWHM). The geocorona is manifested as an absorption feature when the absorption of the coronal radiation is greater than the geocoronal emission (which is due to scattering
Fig. 2. H I Ly α profiles from a) 1.5, b) 2.5, and c) 3.5 R⊙ along the streamer axis. Solid points are detector counts with ±1σ uncertainties.

of radiation from the chromosphere). The net geocorona contribution to the profile can be positive or negative depending on whether the geocoronal “dayglow” is greater than or less than the total absorption in the solar coronal profile. The profile in Figure 2a is an example where there is a net absorption at the profile peak. The profiles in Figures 2b and 2c show the opposite case where there is a net emission.

To determine the true profile for the solar coronal radiation alone, each observed profile is fitted by the sum of two gaussians. A narrow gaussian which has an 1/e width that is the same as the instrument profile is normalized so that its intensity equals the net geocoronal contribution. The second gaussian is an approximation of the true coronal profile. In actuality, coronal profiles are not gaussian because of the line of sight effects of the resonant scattering process (Withbroe, et al. 1982) The gaussian profile fits are only used to approximate the proton rms velocity distribution along the line of sight. In a more detailed analysis, the observed profiles are to be compared with the profiles produced from a line of sight integrated model. The simple gaussian approximation for the coronal profiles is appropriate for the streamer if it is localized near the plane of the sky.

The 1/e widths of the fitted profiles can be used to derive a proton kinetic temperature which can be ascribed to both thermal and non-thermal motions of the particles. We define the relation between the coronal 1/e width Δλ and the kinetic temperature T_k by Δλ = \( \frac{λ_0}{c} \left( \frac{2kT_k}{m_p} \right)^{1/2} \), where the symbols k, c, m_p have their usual meanings and λ_0 is the Ly α line center in the hydrogen rest frame. The results for the kinetic temperature as function of heliocentric distance are shown in Table I. Uncertainties (1 σ) in each temperature value is about 0.25 × 10^6. The kinetic temperature is approximately constant with a hint of a peak temperature at 2.1R⊙.
TABLE I
Proton kinetic temperatures corresponding to Doppler widths of the observed coronal H I Ly α profiles.

<table>
<thead>
<tr>
<th>Heliocentric Height (R⊙)</th>
<th>Kinetic Temperature (K)</th>
</tr>
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<tbody>
<tr>
<td>1.5</td>
<td>2.6 × 10^6</td>
</tr>
<tr>
<td>1.8</td>
<td>2.9 × 10^6</td>
</tr>
<tr>
<td>2.1</td>
<td>3.2 × 10^6</td>
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<tr>
<td>2.5</td>
<td>3.0 × 10^6</td>
</tr>
<tr>
<td>3.0</td>
<td>2.7 × 10^6</td>
</tr>
<tr>
<td>3.5</td>
<td>2.2 × 10^6</td>
</tr>
</tbody>
</table>

3. Discussion

One explanation for the nearly constant total line widths is that the thermal and nonthermal components compensate (one decreases by the same amount as the other increases) over the interval, 1.5 ≤ r ≤ 3.5R⊙, along the streamer axis. This possibility, while unlikely, must be investigated with appropriate models that include turbulence and nonthermal heating. It is more likely that the streamer profiles are produced from an an extended region (e.g., a streamer arcade) where there are velocity outflows toward and away from the observer. The weakness in this hypothesis is that there is no large change in the profile widths when streamer configuration changes from a closed to an open (radial) flow configuration. (For the observed streamer, it appears that the field lines open up near 3 R⊙.)

Future work for the data analysis involves building an empirical model of the streamer and its surrounding regions in order to test whether or not the H I Lyα intensities and profiles can be predicted. The model will include the spatial dependences for the electron and proton temperatures, densities and outflow velocities.

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References