SHIFTS OF THE CaII K LINE IN HeI 10830 DARK POINTS

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Abstract. We investigate the velocity field of the solar chromosphere at the location of 65 HeI 10830 dark points (DP's). We have obtained spectra of such points in the vicinity of the CaII K line. As a measure of differential chromospheric velocity, we use the shift of the K line center relative to a nearby photospheric FeI line. We find that in HeI DP's, the distribution of K line shifts is skewed towards the blue: the blueward skewing is more pronounced in HeI DP's located in coronal holes. To the extent that HeI DP's are proxies of coronal bright points, our study is relevant to previous reports of outflows from such bright points.

1. Introduction

Solar mass loss is usually considered as a purely coronal phenomenon, with little or no detectable signature at chromospheric levels. If the mass loss were spherically symmetric, the chromospheric signatures would indeed be negligible. However, certain observational results suggest that the sources of the solar wind depart markedly from spherical symmetry.

Thus, high-speed streams emerge preferentially from coronal holes (e.g., Zirker, 1981). More specifically, Ahmad and Webb (1978) have suggested that the wind may be emerging from a small number of compact sources (X-ray bright points) in coronal holes. Davis (1980) has shown that the areal density of bright points in coronal holes is positively correlated with solar wind density. Coronal bright points are known to be correlated with dark points in HeI 10830 spectroheliograms (Harvey et al., 1974; Harvey and Sheeley, 1977). In view of this correlation, it is noteworthy that Harvey (1985b) has reported that the areal density of HeI dark points in coronal holes may also be correlated with solar wind properties, although the correlation may depend on the phase of the solar cycle. Brueckner and Bartoe (1983) have also suggested that the solar wind may be emerging from many small discrete 'jets'.

If there are radical departures from spherical symmetry in the solar wind sources, then chromospheric signatures of mass loss may be considerably larger than previously suspected.

In this work, we study the CaII K resonance line in the vicinity of HeI dark points (DP's) in order to investigate whether the velocity field in the chromosphere in a DP differs from that in random areas of the quiet Sun. To the extent that DP's are proxies of coronal bright points, our results provide information about the chromospheric velocity field beneath such bright points.
In Sections 2 and 3, we describe our techniques and our data, and we discuss the results in Section 4.

2. Data Acquisition: Target Identification

To identify DP's and coronal holes, we use spectroheliograms taken in the He I 10830 Å line at the National Solar Observatory Vacuum Telescope on Kitt Peak (Livingston et al., 1976). The He I 10830 image is relayed via telephone multiplexer (Colorado Video Expander 275) to the Swarthmore/Bartol Observatory, where the image is recorded digitally and also displayed on a video monitor. The resolution of the digital image is approximately 8 arc sec per pixel.

Spectroheliograms in He I 10830 are recorded once per day at Kitt Peak. Each spectroheliogram requires some 45 min to complete. We receive the image within minutes after its completion. For each spectroheliogram, we find the center of the solar disk by triangulation from points on the circumference. We then locate our target DP's for the day and determine their positions with respect to the center, allowing for the solar tilt angle and for solar rotation. Transforming DP coordinates to locations in our focal plane, we position each DP in turn on the entrance pinhole of our spectrometer. We begin recording Ca II K spectra at the first DP location within 0.5–1 hr of receiving the He I image from Kitt Peak. Since DP lifetimes are on the order of hours (Holt et al., 1986), the DP properties should not have altered significantly between the time the Kitt Peak spectroheliogram was obtained and the time we obtain Ca II K spectra.

Our procedure for positioning a DP target in the spectrometer pinhole is uncertain by an amount which may be as large as about 10 arc sec. Most DP's are of order 10–30 arc sec in size. We do not know whether associated features in Ca II K light have the same size.

Coronal holes are identified as areas where the He I 10830 image is brightest (see Figure 1). The degree of correlation between coronal holes and bright areas in He I 10830 may vary during the solar cycle, especially for small holes (Kahler et al., 1983). Despite this possible source of uncertainty, we have selected coronal holes on the basis of bright areas on the He I images. Some DP's lie inside coronal holes, others lie outside: we investigate DP's in both locations. Our interest in Doppler signatures of radial outflows restricts us to considering DP's and coronal holes at low latitudes.

3. Data Acquisition: Ca II K Spectra

The telescope is a 61-cm Cassegrain reflector mounted in a fixed position pointing towards the north pole in a laboratory on top of a 50-foot building on the campus of Swarthmore College. The telescope is fed by a 91-cm polar heliostat mounted on the roof. The solar image has a scale of 16 arc sec mm⁻¹. In our spectrometer (Wyller and Fay, 1972), a rotating echelle grating in Czerny–Turner configuration allows us to scan the spectrum. The entrance pinhole (0.1 mm) corresponds to 1.6 arc sec on the Sun. The exit slit size (0.007 mm) corresponds to a wavelength channel of 0.02 Å.