C Ⅳ PLASMA FLOW NEAR ACTIVE REGION FILAMENTS

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Abstract. Selected C Ⅳ $V_0$ lines (lines separating adjacent regions of strong blue shift and strong red shift) located near the solar limb and oriented parallel to the radius vector from disk center are shown to be closely aligned with Hz dark filaments in active regions. The filaments, in turn, are known to lie in the vicinity of magnetic neutral lines. The radial orientation of the $V_0$ lines minimizes uncertainties in image registration and their location near the limb ensures that the observed fluid motion has major components paralleling $V_0$. It follows that the filaments are located at sites of velocity shear, and, by inference, of magnetic shear. For a case in which a given $V_0$ line is observed near both east and west limbs, the gradient of Doppler velocity across the $V_0$ line reverses sign from one limb to the other as is expected for horizontal steady flow. Thus, the velocity vectors remain fixed with respect to the filament.

1. Introduction

Studies of velocity patterns observed in the C Ⅳ (1548 Å) transition region line using the Ultraviolet Spectrometer/Polarimeter (UVSP) experiment on the Solar Maximum Mission (SMM) satellite have established a number of important relationships between the velocity patterns and both photospheric magnetic fields and chromospheric Hz features (cf. Athay et al., 1982; Athay, Gurman, and Henze, 1983; Athay, Jones, and Zirin, 1985; Engvold, Tandberg-Hanssen, and Reichmann, 1985; Klimchuk, 1989). In addition to these established relationships, the previous studies have also raised a number of questions yet to be resolved. Two such questions involving active region dark filaments and the channels of weak magnetic fields in which the filaments lie can be stated as follows: (1) How closely do the filaments lie to the C Ⅳ $V_0$ lines (lines along which the velocity changes sign from relative blue shift to red shift)? and (2) why do the filament channels (weak field corridors in Klimchuk's (1987) notation) show a preference for a relative blue shift regardless of where they are on the solar disk? Klimchuk (1987) has noted, for example, that $V_0$ lines associated with filament channels appear to be located preferentially near the sides of the channel whereas the dark filaments may lie anywhere within the channel. This leads to a situation in which some filaments appear to be closely associated with $V_0$ lines whereas others appear to be surrounded by the relative blue shift within the channel. Blue shifts in filaments and their surroundings have been reported also by Schmieder et al. (1984) and Malherbe et al. (1983). On the other hand, there is compelling evidence that some filaments lie essentially along $V_0$ lines (cf. Engvold, Tandberg-Hanssen, and Reichmann, 1985; Athay, Jones, and Zirin, 1985; Athay, 1985).

Much of the diversity in the preceding results can be attributed to uncertainties

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involved in coregistering data from disparate instruments and taken at different times. Errors in registration inevitably occur and can be relatively large. This leads to cases in which features that are actually coincident appear to be significantly displaced. The opposite may also occur, but is less likely. In this study we minimize the errors in coregistration by selecting cases involving linear features oriented radially with respect to disk center. For such features small differences in image sizes and errors in radial location are relatively unimportant. The primary errors are in registration of the solar rotation axes and in correcting for lateral displacements due to solar rotation during the time interval between the different data sets.

For purposes of this study, we select a small subset of the large (240' × 240') UVSP Dopplergrams that meet two criteria: (a) a long or moderately long $V_0$ line located near the limb and oriented approximately radially from disk center, and (b) a nearby $\text{H}_\alpha$ dark filament. For the latter criterion, we used the $\text{H}_\alpha$ patrol data at Big Bear Solar Observatory. Each criterion is quite restrictive. A vast majority of prominent $V_0$ lines have a non-radial orientation and the $\text{H}_\alpha$ data cover only limited periods of time. The final data set includes six Dopplergrams made in three different active regions. Each of these regions has been included in earlier studies by Klimchuk (1986, 1987, 1989), but his studies did not emphasize the particular $V_0$ lines selected for the present study. An additional region (NOAA 2517) that satisfies our criteria was omitted because a detailed study of the region by Athay, Jones, and Zirin (1985) showed a close and unambiguous alignment between the $V_0$ line and a long $\text{H}_\alpha$ filament.

Careful studies of the alignments of $V_0$ lines relative to magnetic neutral lines as well as the alignments of $V_0$ lines relative to $\text{H}_\alpha$ filaments are reported in the studies by Klimchuk (1986, 1987, 1989). The present work selects a small subset of the velocity data particularly suited for study of the $V_0 - \text{H}_\alpha$ alignment. Although magnetograms are used to facilitate the $V_0 - \text{H}_\alpha$ alignment, we do not re-examine the $V_0$-neutral line alignments given by Klimchuk.

The data used in this study, on inspection of the $\text{H}_\alpha$ images, appear to include a case of a filament channel that is observed near both east and west limbs. The apparent channel contains a long dark filament with paralleling fibrils and lies between two nearby active regions, 2469 and 2470. Upon inspection of the magnetograms, however, we find that the magnetic field is rather complex and of moderate strength within this apparent channel. In addition, the field pattern within the apparent channel evolved considerably during disk passage. Thus, we cannot regard this as a typical filament channel (or weak field corridor in Klimchuk’s notation). On the other hand, we can follow the velocity and magnetic pattern associated with the filament near both east and west limbs, which sheds some light on the dilemma posed by the apparent blue shift of the filament channels.

Klimchuk (1987) speculates that the apparent blue shift in filament channels and near some $V_0$ lines is most likely an artifact of setting the average raster velocity to zero rather than to a net red shift. This is a logical supposition near disk center where $\text{CIV}$ Doppler shifts measured relative to chromospheric lines are predominantly red shifted at an amplitude of several km s$^{-1}$ (Doschek, Feldman, and Bohlin, 1976; Roussel-Dupre