Spectro-Polarimetric Observations of Filaments in H\(\alpha\) and He\(\text{I}\) D\(3\)

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Abstract. Recordings of the full Stokes vector of filaments in the H\(\alpha\) and He\(\text{I}\) D\(3\) lines were obtained at the Gregory-Coudé telescope in Locarno with the polarimeter ZIMPOL. The aim was to perform preliminary studies to explore the presence of forward scattering polarization. The observations show linear polarization signatures, whose interpretation is still being investigated, although it seems likely that forward scattering is indeed involved.

1. Introduction

Transverse magnetic fields in solar filaments observed at disk center can generate linear polarization signatures through the forward Hanle scattering. The diagnostic interest of this effect was pointed out by Trujillo Bueno (2001), and its signature has been detected in filaments observed in the He\(\text{I}\) 10830 Å line (Trujillo Bueno et al. 2002). To explore if signatures of the forward Hanle scattering can be detected in filaments in H\(\alpha\) and He\(\text{I}\) D\(3\), we performed preliminary spectro-polarimetric observations at IRSOL, choosing to observe quiescent filaments near disk center. Here we report only the observational results, postponing their interpretation to a future paper.

2. Observations

Observations of filaments were performed with the Gregory-Coudé telescope at IRSOL, using the Czerny-Turner spectrograph and the polarimeter ZIMPOL (Gandorfer et al. 2004). 19 measurements were performed in H\(\alpha\) and 6 in He\(\text{I}\) D\(3\). The polarimeter was set so to measure as positive \(Q/I\) the linear polarization parallel to the spectrograph slit. For practical reasons it is more convenient to define as positive \(Q/I\) the linear polarization parallel to the local direction of the filament. The slit jaw-image was used to identify the orientation of the filament with respect to the slit, and rotation of the Stokes vector could then be done numerically.

To reach a good signal-to-noise ratio, exposures ranging from 10 min to 130 min (for He\(\text{I}\) D\(3\) recordings) were needed. The automatic guiding system (Küveler et al. 1998) was used to compensate for the solar rotation.
2.1. Hα Observations

Polarization signatures were found in our observations of filaments in Hα. The observation reported here was performed on March 18, 2005 at longitude 2° and latitude 11° starting at 08:00 UT and lasting about 1 h. Figure 1 is a low resolution slit-jaw image of this filament, used to find its orientation with respect to the slit. The results of this measurement are representative of most of our other Hα observations of filaments. The linear polarization parallel to the local filament direction, defined as \( Q/I \), generally shows a peak at line center, while in \( U/I \) peaks are located in the wings of the line.

Figure 2 shows the four Stokes images of a spectral interval around Hα. The darkest area in the line core in the intensity image is due to the filament. At the same place signatures in \( Q/I \) and \( U/I \) were detected. The \( V/I \) image does not show any particular signal in the filament, but only a small antisymmetric signal in the neighbourhood.

The vertical white lines drawn at 6563.6 Å mark the spatial interval (from 67″ to 94″) along which the Stokes profiles reported in Fig. 3 are averaged. The two intensity profiles in Fig. 3 correspond, respectively, to this interval in the filament (solid line), and to an interval from position 5″ to 30″ outside of it (dot-dashed line). The \( Q/I \) and \( U/I \) profiles show peaks, respectively at line center and in the wings, with amplitudes of the order of \( 10^{-3} \).

2.2. He i D3 Observations

Observations of filaments in He i D3 revealed the presence of faint polarimetric signatures in the \( 10^{-4} \) range. Long exposure times were required to reach adequate signal-to-noise ratio. The filament measurement reported here was performed on March 19, 2005 at longitude 13°5 and latitude 16°5 starting at 11 UT and lasting 130 min.
Figure 2. Hα Stokes images of the region shown in Fig. 1. The darker area in the intensity image comes from the observed filament. The nature of the linear polarization signatures seen in this filament, and confirmed also in other filament observations, is not yet fully understood.

Figure 3. Hα Stokes profiles averaged along the vertical white lines in Fig. 2. Positive Q is defined as the linear polarization parallel to the local direction of the filament.
In Fig. 4 we report the four Stokes images showing the faint He i D₃ signatures. In the intensity image, around 5875.5 Å, one can recognize a faint darkening due to the filament. The corresponding Q/I signature can be noticed. The vertical white line drawn at 5876.2 Å represents the spatial interval along which the profiles in Fig. 5 are integrated (from 40'' to 65''). The two intensity profiles in Fig. 5 are integrated along this interval (solid line) and along an interval (104'' to 120'') outside the filament. The vertical markings correspond to the wavelengths of the He i D₃ multiplet.

The Q/I plot shows signatures in both the blue and red components of He i D₃. This profile shape is very similar to the ones already measured in prominences and in spicules (Ramelli et al. 2006). Note the very faint Q/I amplitude, with a peak of about $2 \times 10^{-4}$. This signature can be interpreted in terms of the forward-scattering Hanle effect.

3. Conclusion

Observations of filaments in Hα show the presence of certain shapes of the linear polarization profiles. Defining $Q$ as the linear polarization parallel to the filament direction, we find that $Q/I$ peaks in the line center, while $U/I$ peaks in the line wings, both with amplitudes reaching a few $10^{-3}$. The interpretation of these signals is not straightforward, and probably several physical effects are involved, like forward scattering in the presence of inclined fields in a medium whose optical thickness at the Hα wavelength is significant.

Filaments observed in He i D₃ also show linear polarization signatures, with profiles that are similar in shape to those observed in prominences and spicules.
Figure 5. He I D$_3$ Stokes profiles averaged along the vertical white lines drawn in Fig. 4. The amplitude of the $Q/I$ peak is only $2 \times 10^{-4}$.

Such signals can be interpreted in terms of forward Hanle scattering. The amplitudes measured in quiet filaments are in the range of a few $10^{-4}$.

The observations presented here represent an explorative work to prepare a more definite campaign using the ZIMPOL polarimeter either with the spectrograph or with the Fabry-Perot filter (Feller, Boller, & Stenflo 2006).

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References

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