Search for Alfvén waves in a bright network element observed in Hα

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Abstract: The poster reports on an attempt to detect spectroscopic signatures of the Alfvén waves in the chromosphere occupied by a bright network element, investigating temporal variations of the width, the intensity, the Doppler shift, and the asymmetry of the core of the Hα spectral line observed by the Dutch Open Telescope (DOT). The bright network element displays the most pronounced variations of the Doppler shift varying from 0 to 4 kms^{-1} about the average of 1.5 kms^{-1}. This implies a persistent redshift of the Hα core with a redward asymmetry of about 0.5 kms^{-1}. The core intensity variations lag behind the Doppler shift variations about 2.1 min. We found a striking anticorrelation between the core asymmetry and the Doppler shift, suggesting a change of the core asymmetry from redward to blueward with an increasing redshift of the Hα core. The data and the applied analysis do not show meaningful tracks of Alfvén waves in the selected network element.

Introduction

Alfvén waves have been invoked as one of possible mechanisms heating the solar corona. They are capable of penetrating through the solar atmosphere without being reflected and refracted. Since they are incompressible, their propagation is not associated with density changes seen as periodic variations of intensities and LOS velocities. Observation of a slanted magnetic fluxtube could reveal them as periodic variations of nonthermal spectral line broadening. This approach was employed in Jess et al. (2009) who found periodic oscillations of nonthermal broadening of the Hα spectral line seen over a cluster of bright points associated with a distinct upflow without significant periodic variations of intensities and LOS velocities. They interpret this as a manifestation of Alfvén waves in the solar atmosphere.

Aims

Motivated by the results of Jess et al. (2009), we search for signatures of Alfvén waves in a bright network element. We investigate Hα spectral characteristics, focusing on temporal variations of the line core width, intensity, Dopplershift, and the asymmetry derived by polynomial fitting of a five-point sampling of Hα.

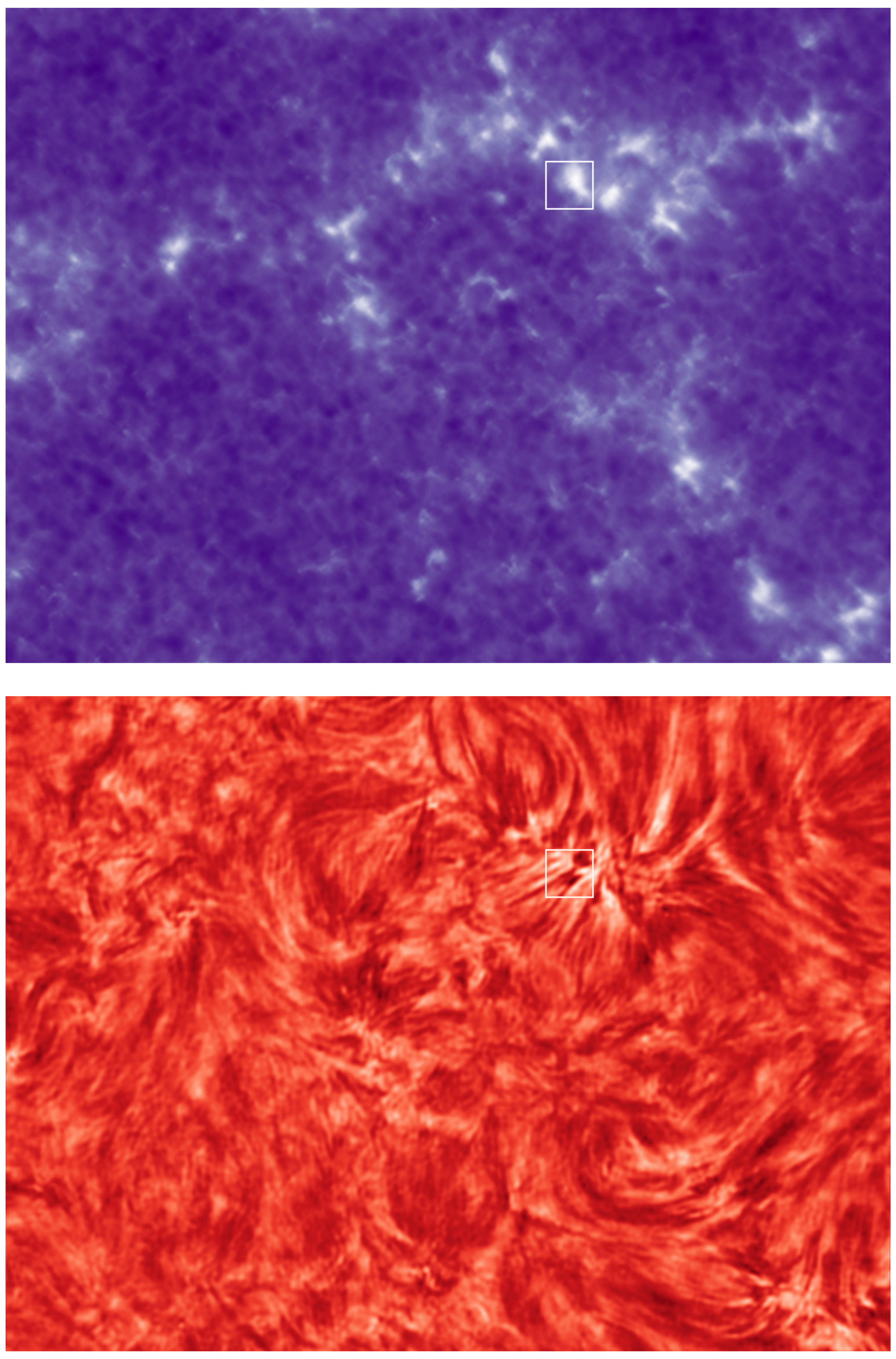

Figure 1. Images of the quiet-Sun network recorded by DOT on 19 October 2005. *Top:* the temporal mean of the Ca II H image sequence over its 71-min duration. *Bottom:* the Hα line center image taken at the moment of the best seeing. The square of size 4.3 × 4.3 arcsec^2 defines the network element selected for this study.

Observations

We use sequences of Hα images of a very quiet area near the disk center recorded by DOT on 19 October 2005 by the tunable Lyot filter with a FWHM = 0.25 Å. The sequence consists of 71 scans with 60-s cadence taken in five wavelengths across the Hα line profile: line center, ±0.35 Å, and ±0.7 Å. A time step between the five-wavelength scans of the Hα line profile is 60 s. As a context data, we also use the sequence of 142 Ca II H images taken synchronously with the Hα images. The temporal mean of the Ca II H images and an example Hα image are shown in Fig. 1. The square defines the network element selected for this study.

Spectral characteristics

We construct 71 proxy profiles of the Hα line core by spatial averaging of intensities within the selected network element (Fig. 1) at each wavelength. Spectral characteristics of these spatially averaged intensities are determined from their 4th-order polynomial fits. We fit the five-wavelength samples of the proxy profiles by a 4th-order polynomial to derive the four profile measurements: the core intensity I_C, the core velocity v_C, the core width *FW*, and the bisector velocity v_{BI}. The values of I_C and v_C represent the fit minimum and its Doppler shift, respectively. The core width *FW* is the wavelength separation of the two fit flanks at half of the intensity range between the fit minimum and the average of the endpoint intensities at ±0.7 Å. The bisector velocity v_{BI} quantifies an asymmetry of the line core fit with respect to its minimum.

Results

The top panel of Fig. 2 shows the relative variations of the fit width and the core intensity of the line core fits of Hα in the selected network element (Fig. 1) with respect to their temporal means. The bottom panel shows variations of the core and bisector velocity, whose positive values indicate redshift and redward asymmetry of the line core. The Fourier cross correlation indicates that the core intensity variations lag behind velocity variations about 2.1 min on average (Fig. 3). The Hα core possesses mostly a redward Dopper shift and asymmetry. Selected spectral characteristics from Figs. 2 and 3 are displayed in the form of scatter plots in Fig. 4. The right panel suggest a striking anticorrelation between bisector and core velocity. The profiles with the zero Dopplershift display a redward asymmetry with v_{BI} = 1 kms^{-1} and become symmetric for v_C of 2 kms^{-1}, but tend to display an increasing blueward asymmetry with increasing redshift.

Discussion and conclusion

We derived spectral characteristics of the Hα spectral line observed in the network element with the aim of seeking signatures of the Alfvén waves as reported in Jess et al. (2009). How do our findings compare to the results of these authors?

While Jess et al. (2009) reported an average blueshift of 23 kms^{-1} in a cluster of Hα bright points, we found an average redshift of about 1.5 kms^{-1}. Further, they reported an absence of any significant intensity variations in the cluster. Our results suggest that the core width variations in the selected network element are associated with both the core velocity and intensity variations. Finally, the authors detected FWHM oscillations of the Hα spectral line with the strongest power in the 400-to-500 s interval. We conclude that, most likely, a different mechanism works in the selected network element than in the cluster studied by Jess et al. (2009).

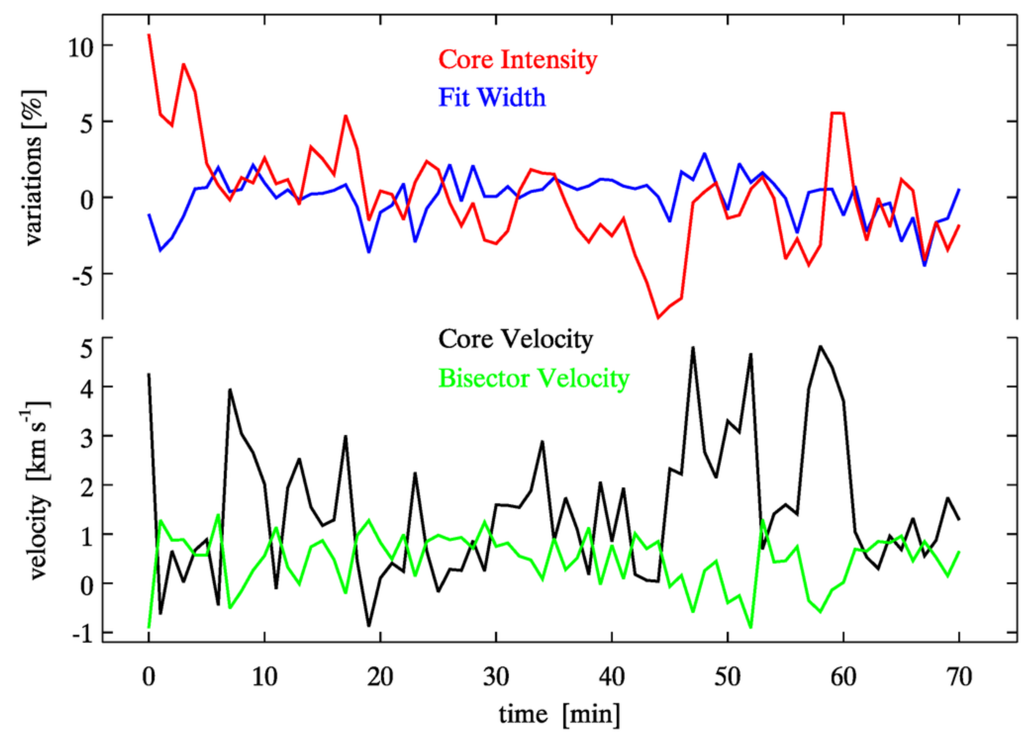

Figure 2. Temporal variations of the fit width *FW*, the core intensity I_C, the core velocity v_C, and the bisector velocity v_{BI} of the line core fit of the Hα spectral line in the selected network element (Fig. 1) derived by the 4th-order polynomial. *FW* and I_C are shown as variations with respect to their temporal means. Positive v_C and v_{BI} signalize a redshift.

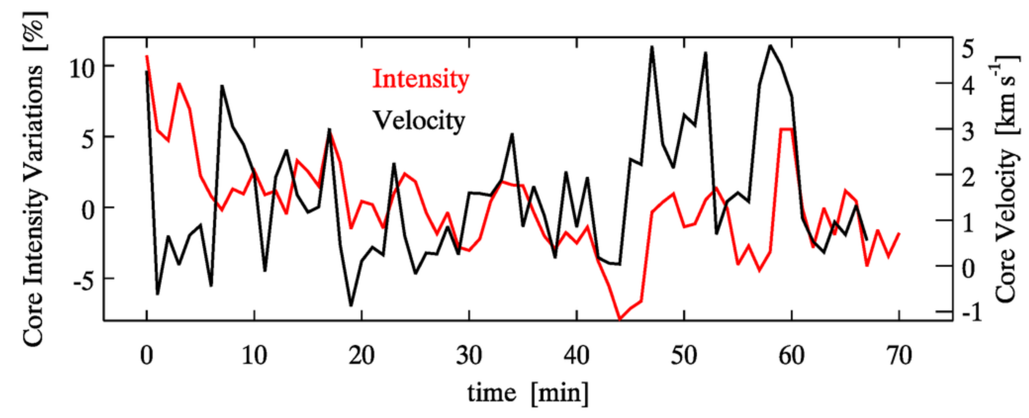

Figure 3. Temporal evolution of the core velocity and intensity from Fig. 2. Time lag of intensity behind the velocity in the network element is apparent after the 40th minute.

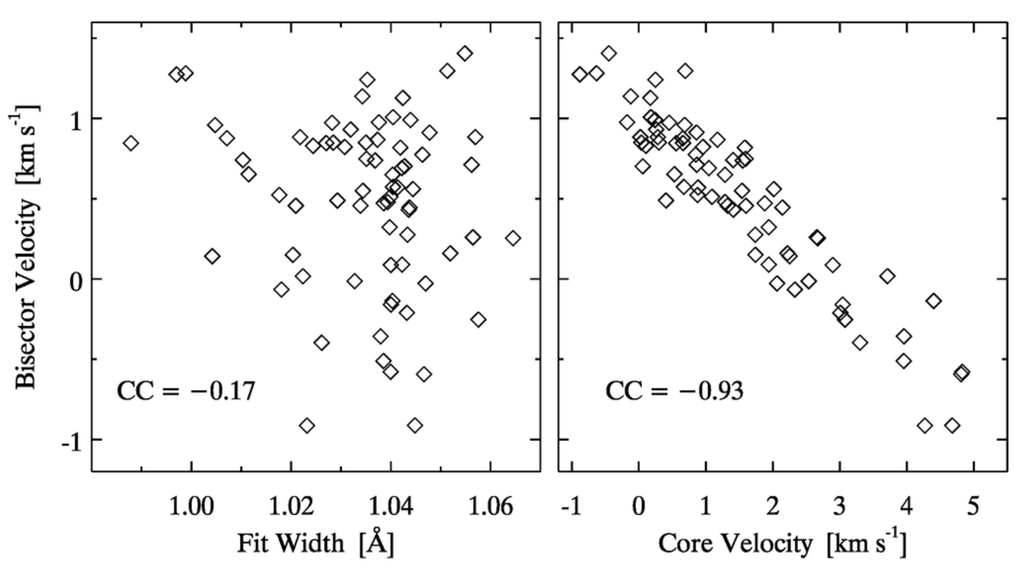

Figure 4. Scatter plots of selected spectral characteristics. Unlike Fig. 2, the plots show absolute values of fit width. Positive core and bisector velocity signalize a redshift. There are also shown the correlation coefficients CC.

References

Jess, D.B., Mathioudakis, M., Erélyi, R., Crockett, P.J., Keenan, F.P., Christian, D.J.: 2009, Science, Vol. 261, p. 321.

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