Variability of Mg II h&k Lines in the Quiet Sun

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Introduction

The aim of this work is to investigate the spatial and temporal variability of the Mg II h&k lines in the Quiet Sun. Mg II ions provide a variety of spectral lines of substantial diagnostic potential in the solar atmosphere, particularly between the upper photosphere and the upper chromosphere. Characterising the temporal and spatial variability of Mg II emission in the solar atmosphere allows to

- probe the variations of physical conditions where the h and k lines are formed, and
- assess the impact these variations may have on chromospheric structures illuminated by the Sun's radiation in these lines.

In this work we seek to derive information on the spectral features of the Mg II h&k lines in the quiet sun at the centre of the sun. We present a novel approach for automatically determining the positions of the outer minima in the red and blue wings (k1r, h1r, k1v, h1v), line emission peaks in the red and blue sides (k2r, h2r, k2v, h2v), and the central absorption cores (k3, h3) in the spectroscopic observations obtained by IRIS at quiet sun centre (Fig 1).

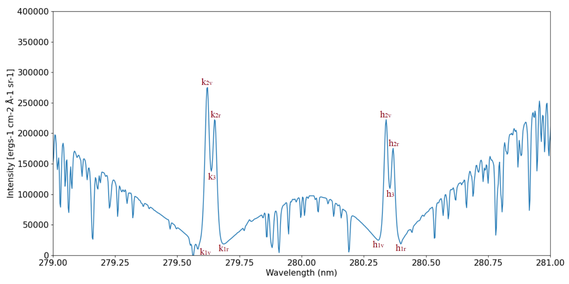

Figure 1:IRIS spectrum of Mg II h&k lines at 2796 and 2803 Å at Sun's centre (23 July 2019 04:25UT).

Methods

To identify the minima and maxima of interest, we

- calculate differences in intensity across the line,
- look for the sign of all these values,
- take the difference between all these values.

Positive (negative) differences in sign between two consecutive points correspond to a local minima (maxima). Unwanted minima or maxima are filtered out based on relative values.

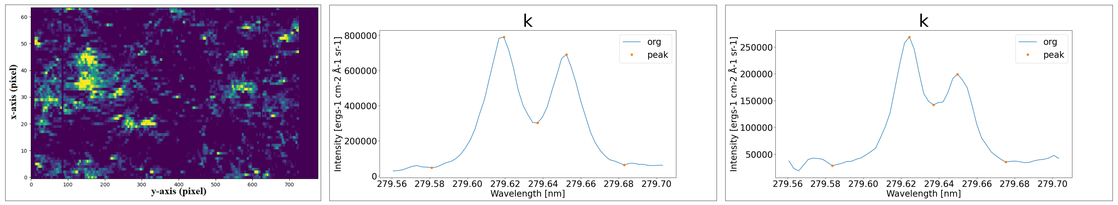

Figure 2:Mg II k spectra for two different pixel locations showing the variation of intensity in the raster taken on July 23, 2019. The left image represents a spectroheliogram in k line (in pixel) . The middle image describes a bright region at pixel location [30, 40], while the right image describe a darker region at pixel location [10, 380]. The five orange points on the line profiles show the positions of the spectral features of interest automatically obtained by our algorithm.

Wavelength and Intensity Histograms

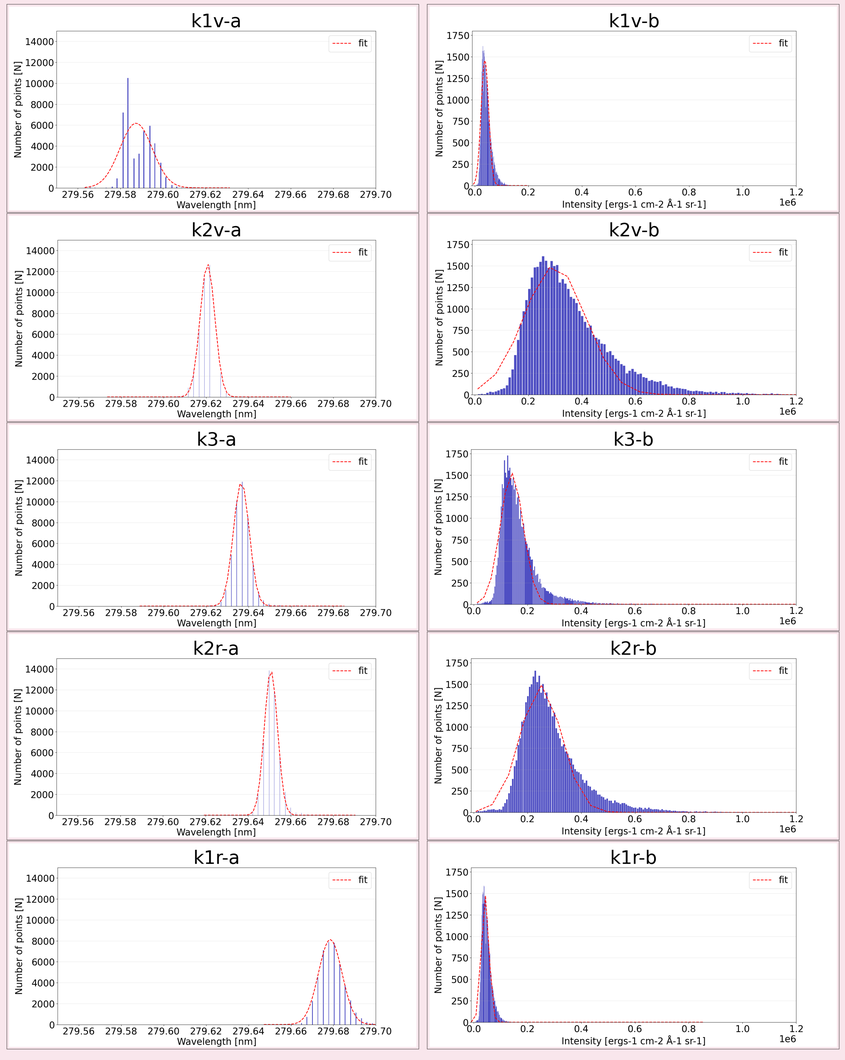

Figure 3:Wavelength (left) and intensity (right) histograms for the profiles features of Mg II k in the raster taken on July 23, 2019. The dashed red line represents a Gaussian distribution.

Results

Figure 2 shows the result of our algorithm on two example k line profiles. Figure 3 shows histograms of wavelengths and intensities of the spectral features of interest for the k line for all pixels in the raster.
The wavelength histograms are relatively well described by Gaussian distributions, while the intensity histograms are clearly asymmetrical. The spread in wavelengths is clearly larger for k1v and k1r, which is expected because of the lower intensities and greater difficulty to identify these features. The wavelength histograms in k3 provide information on the velocities in the upper chromosphere, while intensity histograms in k3 give an indication of the transition region height, where these features are formed. The spread and differences in k2v and k2r histograms suggest variations in temperature and velocities of the chromospheric regions where these peaks are formed (Pereira et al., 2013). The intensity histograms allow us to explore the relative contributions of different quiet Sun features to the total emission in the Mg II lines.

Conclusion

A new method for automatically determining the positions of the Mg II h&k spectral line features has been developed.
This preliminary analysis on a single IRIS raster demonstrates there is a wealth of information that can be obtained from the complex Mg II line profile shapes by studying their key features automatically.
We are now working on applying this code to all quiet Sun rasters obtained between 2014 and 2021 to investigate the temporal variation of Mg II h&k lines, and we will subsequently explore the centre-to-limb variations.

References

- Pereira et al., 2013, ApJ, 778(2), p.143.

Acknowledgements

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