Investigation of quiet sun from IRIS center-to-limb observations

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Introduction

The Interface Region Imaging Spectrograph (IRIS) is a NASA SMall EXplorer (SMEX) spacecraft that was launched into a Sun-synchronous orbit by a Pegasus-XL rocket on June 27, 2013. IRIS provides simultaneous slit-jaw images and spectra of the photosphere, chromosphere, transition region, and corona. In this analysis, we have used **Si IV 1394** spectral data from IRIS's center-to-limb observations of **Quiet Sun** to study **Doppler velocities** and **spectral line widths** in the transition region.

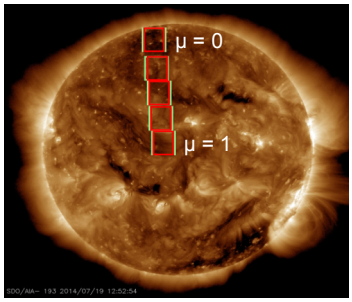

Figure 1. IRIS center-to-limb observation of Quiet Sun taken in July 2014. The bounding boxes for the slit-jaw image and the spectral raster are indicated in green and red, respectively.

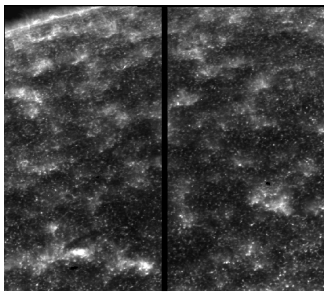

Figure 2. Slit-jaw image taken on July 20, 2014. Note the location of the spectrograph (dark vertical line), which helps us know where IRIS is pointing.

Fitting the Si IV Peak

Figure 3. shows a sample Si IV 1394 spectrum. Here, the Doppler velocity refers to the velocity value under the peak. We calculated the Doppler velocity in three ways:

(1) First moment method (I_1):

$$I_0 = \int I(v)dv \qquad I_1 = \frac{\int I(v)v dv}{I_0}$$

(Total intensity) (Doppler velocity)

(2) GAUSSFIT method: Gaussian fit for data with Doppler velocity between -81.8 and 133.4 km/s. This fit is shown in red in Figure 3.

(3) MPFITPEAK method: Gaussian fit for upper portion of spectral peak that occurs between -81.8 and 133.4 km/s (ignores noise around peak). This fit is shown in blue in Figure 3.

Figure 4. shows that the MPFITPEAK method is the most stable to variations in the Doppler velocity window. Therefore, we used MPFITPEAK to fit the Si IV 1394 peak.

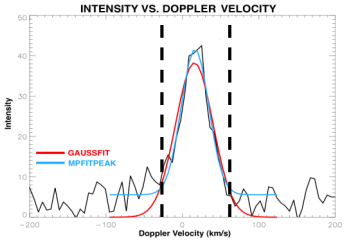

Figure 3. Spectrum with the GAUSSFIT and MPFITPEAK fittings. The Doppler velocity is the value under the peak.

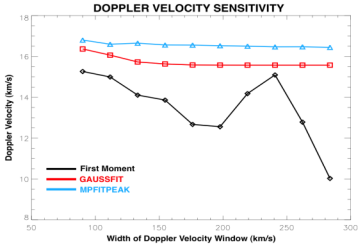

Figure 4. This graph shows the sensitivity of each method to the width of the Doppler velocity window. The initial window used to to calculate the Doppler velocity is indicated by the width of the dashed lines in Figure 3. This initial window is expanded by 10.7 km/s on each side several times. Each time, the Doppler velocity is recalculated.

Doppler Velocity and Spectral Width Histograms

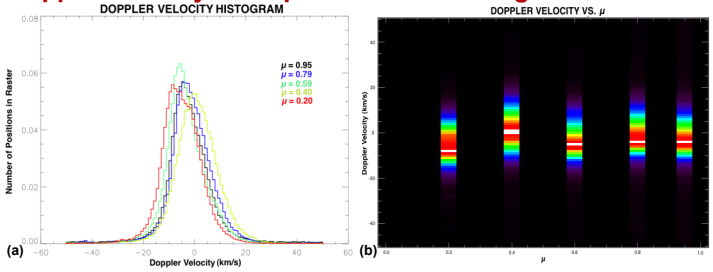

Figure 5. (a) Histogram of the Doppler velocity for observations taken in November 2013. All of the histograms have **similar shapes**, but the position of each maximum is slightly shifted. The Doppler velocity shows a preference for **redshift**. (b) Here, the histograms are plotted as intensity against μ. The variations in Doppler velocity are small and there is a **slight decrease in Doppler velocity at the limb**.

Doppler Velocity and Spectral Width Histograms (cont.)

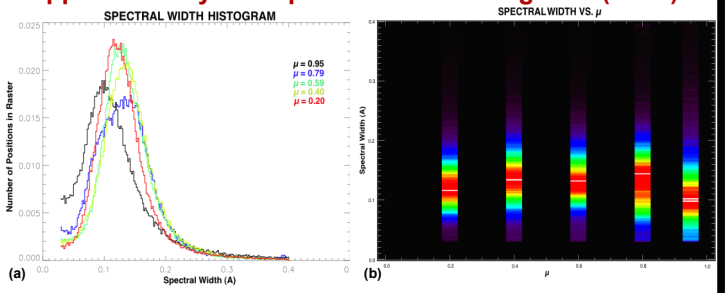

Figure 6. (a) Histogram of the spectral width of the peak for observations taken in November 2013. All the histograms have **similar shapes** but the mean values of the number of points in each raster vary. (b) The histograms are plotted as intensity against μ. The spectral **width decreases near the limb** and the **width of the histogram increases near the center**.

Joint Probability Distribution Functions

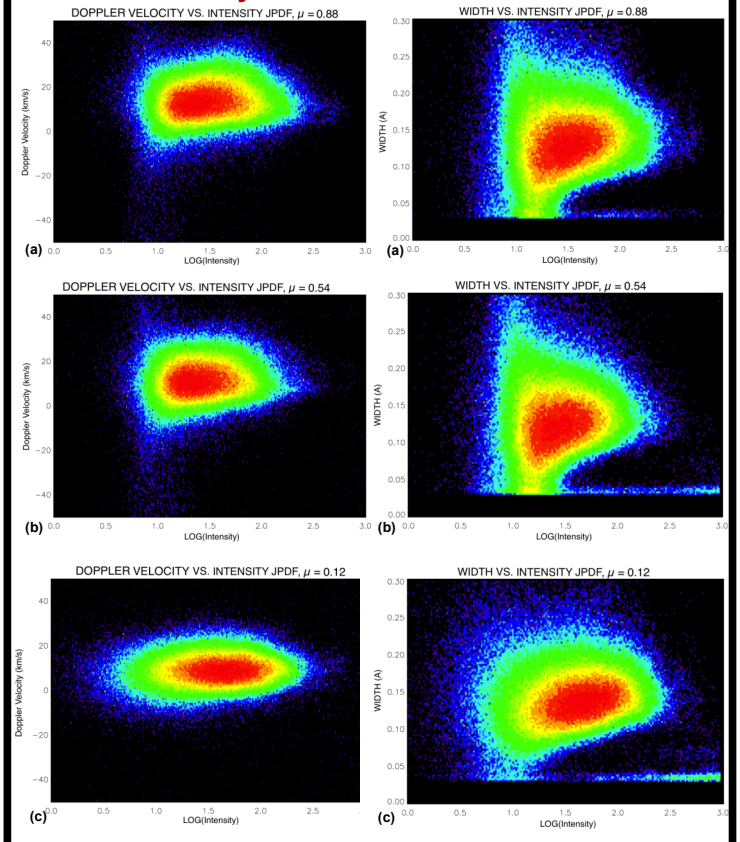

Figure 7. Doppler velocity versus intensity JPDF for observations taken in July 2014. The **Doppler velocity shows a weak dependence on the intensity** of the peak.

Figure 8. Width versus intensity JPDF for observations taken in July 2014. The **width shows a weak dependence on intensity.** This dependence is apparent from **center-to-limb.**

Conclusions

- Si IV 1394 peaks have low intensities with respect to the noise. Therefore, it is important to choose a fitting method that is not sensitive to the Doppler shift window.
- Doppler velocity and spectral width decrease at the limb.
- The Doppler velocity and spectral width show weak dependences on intensity.
- There is a broader range of spectral widths near the center.
- Most of the spectra have widths between 0.06-0.18 Å. These width values are higher than the smallest width that IRIS can detect, which suggests that small scale flows are ubiquitous in the Quiet Sun.

References

De Pontieu et al. (2014), "The *Interface Region Imaging Spectrograph* (IRIS)," *Solar Physics, 289*, doi:10.1007/s11207-014-0485-y.

Acknowledgements

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