A White-light Prominence observed by TRACE

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ABSTRACT

A "white-light prominence" is a flare visible in the continuum above the solar limb. Few examples of this phenomenon have been reported, but the tremendous event of 2003 November 4 was detected by several instruments. This was a partially occulted flare. We report here a detailed study of a much weaker event, seen in this case from a flare whose chromospheric component was on the disk. We find...

Subject headings: Solar flares, X-rays, continuum

1. Introduction

A "white-light prominence" is a white-light flare observed above the limb, projected against the sky. There is almost no literature on this subject, but recently Leibacher et al. (2004) called attention to a remarkable event (2003 November 4) observable via MDI and GONG "pseudo-continuum" imaging, plus weakly as a signal in the total irradiance. Brodrick et al. (2005) estimate the GOES magnitude of this event to have been about X40, using an ionospheric proxy, making it the most energetic solar flare ever recorded.

In normal circumstances the corona is visible in white light via Thomson scattering, thus reflecting the photospheric spectrum as dominated by the continuum. Quiescent prominences are

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Hα filaments seen projected against the sky, whereby the chromospheric emission lines (such as Hα) appear in emission rather than absorption. Loop prominence systems (e.g., Bruzek 1964) are physically entirely different; although also observed in Hα in association with "coronal rain", we know them to be the cooling endpoint of the evolution of flare loops energized initially to X-ray temperatures. The high temperatures would favor continuum emission, which at some level should be detectable spectroscopically. However taking the emission measure directly from the X-ray or microwave bands (e.g., Hudson & Ohki 1972) suggests that the visible spectral intensity in free-free radiation would be undetectably small. Menzel (1961) made an early suggestion identifying white-light flares with such loop prominence systems.

Modern digital detectors, not to mention observatories in space, make much more sensitive observations possible via difference imaging, and we therefore expect a rapid development in our understanding of these processes. We have previously reported detection of white-light flares with GOES magnitudes as small as C1.6 (Hudson et al. 2006) as a part of a survey of TRACE (Handy et al. 1999) and RHESSI Lin et al. (2002) observations of such events. This survey made use of the TRACE "WL" and "1700Å" filters, both of which have strong UV response out to about 1600Å. In the 11-event sample we found two events with clearly coronal emission sources, and we report these in further detail in this paper.

2. Event of 2002 November 12

The Hudson et al. (2006) sample contains one clear example of a white-light prominence, namely the C9.9 flare of (S11, W75) of 2002 November 12. Because this is the first such event described in the literature, we discuss it as fully as possible in this paper. Figure 1 shows images and Figure 2 light curves for this flare. The morphology of the loop prominence system is clearly visible in the 1700Å images, with the highest loops extending just above the limb but the bulk of the emission projected against the disk. Movies in this filter clearly show the coronal rain phenomenon, consistent with the loop-prominence interpretation as well as providing evidence that the 1700Å spectral response includes chromospheric emission lines as well as continuum.

The images (Figure 1) show WL emission at the location of the loop system observed in the UV. The bulk of this emission is projected against the disk, rather than dark sky above the limb. A classical white-light prominence would only be observable above the limb owing to the glare of the photosphere. As noted inHudson et al. (2006) and Fletcher et al. (2006) (papers I and II of this series), however, the spectral response of the TRACE WL filter has strong UV response. One main purpose of this paper is to try to discriminate between true continuum and pseudo-continuum (unresolved emission-line) contributions in this filter, and we address this in the following section. We note that the loop-top WL emission in this event is too faint for a movie representation to show the coronal-rain phenomenon, which would be another clue.

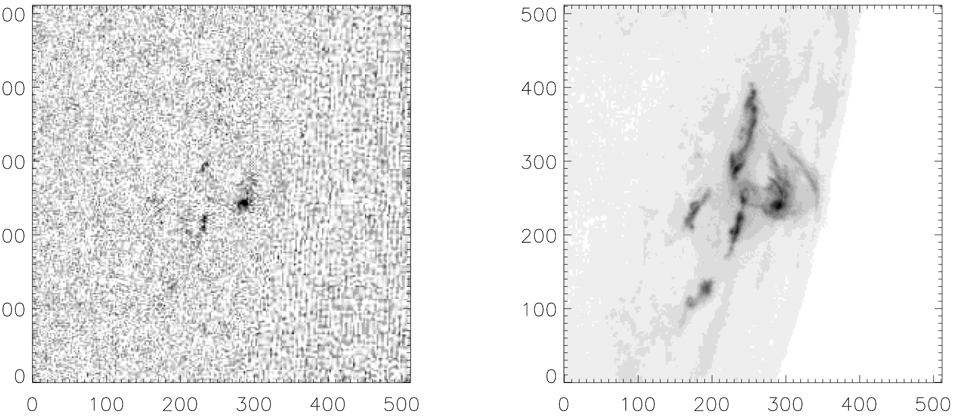

Fig. 1.— Event of 2002 November 12.

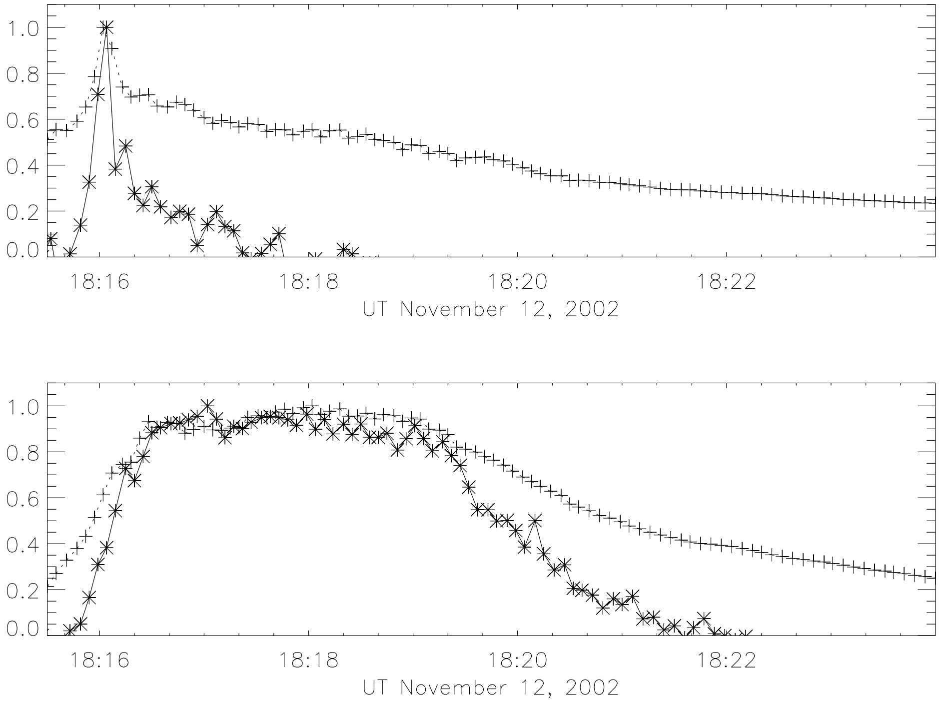

Fig. 2.— Time histories of WL and UV for the event of 2002 November 12 (from Hudson et al. (2006).

3. Spectral information from TRACE filters

This C9.9 event is convenient, because (as shown with image histograms in Figure 3), pixel saturation is not important. The three histograms are for differences relative to a base image at 18:15:30 UT, and are the next image, one at the impulsive peak, and near the maximum of the more gradual peak of the looptop emission.

Fletcher et al. (2006) discuss the use of the spectral ratio UV/WL, formed by taking the excess count rate in the 1700Å filter to that in the WL filter, using a preflare image to estimate the background, This ratio in principle can crudely determine a spectral model such as a blackbody or the Paschen-Balmer model described by Metcalf et al. (2003). From the morphology of this event, one might expect to see diagnostically different spectral ratios for the footpoint and looptop regions. Fletcher et al. (2006) noted, however, that the UV/WL ratio tended always to be about 0.2, even in the different parts of this flare. We illustrate this with the scatterplot in Figure 4, made with a pixel-to-pixel comparison of the WL and UV images at 18:15:54 UT and 18:15:57 UT, respectively, thus separated by only 3 sec. To reduce the scatter a 3×3-pixel smoothing has been applied. The result shows that the footpoints and looptop do not differ substantially from this ratio 0.2, except that the red points (footpoint region) show greater scatter.

4. Analysis

5. Conclusions

[emission lines or continuum???]

6. Acknowledgements

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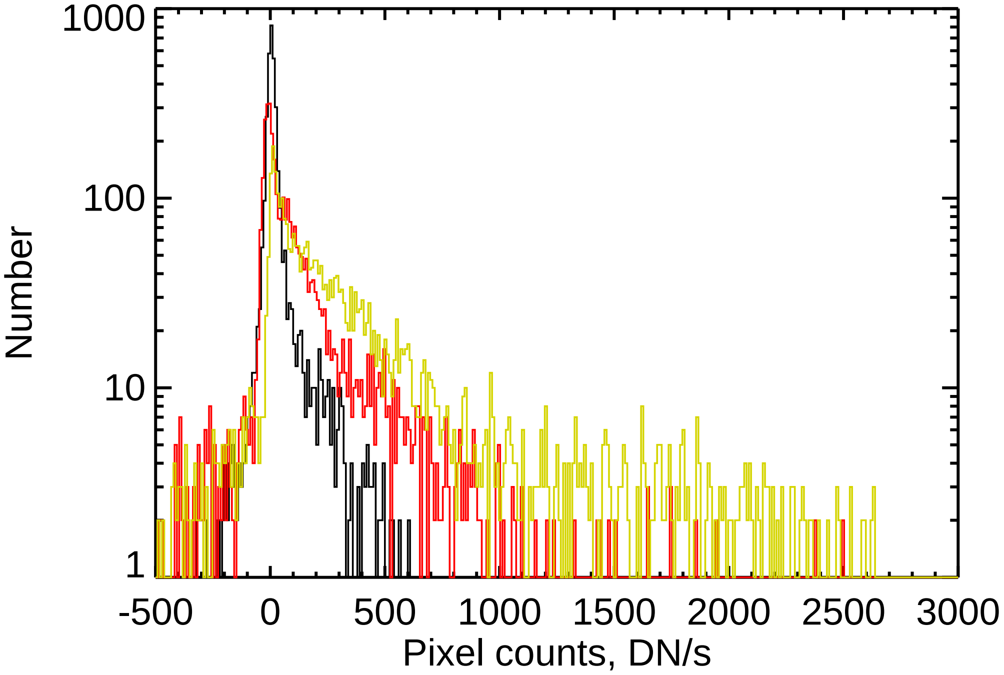

Fig. 3.— Histograms of three 1700Å images (18:15:41 UT, 18:16:02 UT, and 18:18:02 UT).

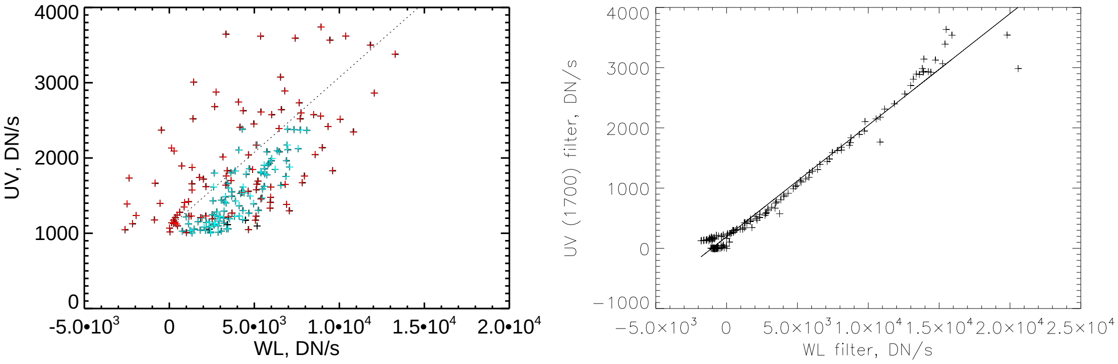

Fig. 4.— (Left: scatterplot of flare excess UV and WL emission, based on a 3×3-pixel smoothing, for images at the peak of the impulsive phase of the 2002 November 12 flare. Red shows the footpoint regions, blue the looptop region. The dotted line shows a ratio of 0.2. Right: similar scatterplot for the much brighter flare of 2002 October 4. Here the slope fits well to a ratio (UV/WL) of 0.185.

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