SHORT DURATION ACTIVE REGION BRIGHTENINGS OBSERVED IN THE EUV AND Hα BY SOHO/CDS AND HIDA/DST

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ABSTRACT

We present the first detection of an Hα counterpart to the EUV blinker, using observations from a coordinated campaign between the SOHO Coronal Diagnostic Spectrometer and the Kyoto University Hida Observatory, Domeless Solar Telescope (DST). The observations were performed during July and August 2002. By designing the CDS observing sequences for high cadence and long duration observations, we were able to identify many short duration (<3 mins.) brightenings simultaneously in the He I 584.334Å and O V 629.732Å spectral lines. These brightenings show similar characteristics (intensity increases, sizes) to longer duration EUV blinkers previously reported in active regions and the ‘quiet’ Sun.

Focusing on two events which show pronounced emission in the upper chromosphere (He I), we have been able to identify coincident bright points in the lower chromosphere (Hα line centre, ±0.5Å) which show enhanced emission during the EUV blinkers. These bright features have similar lifetimes to their EUV counterparts and their peak intensities occur close to simultaneously with the peak blinker intensities in the He I and O V lines. In both cases the He I and O V lines show excess line broadening at the peak of the event (>15 km s⁻¹) and in one event evidence of downward (red-shifted) motion is observed. A statistical study is being performed to provide a complete picture of the line width and velocity characteristics of these events and to determine whether the Hα counterparts are common, or confined to specific blinkers with pronounced He I emission.

The high cadence of our observations also allowed us to examine the effects of spatial and temporal averaging on the determination of the properties of blinkers. We find that both short and long duration blinkers are composed of elementary brightening events and that such events can be undetectable in observations with low temporal cadence. Finally, the Hα brightenings appear to correlate well with the elementary EUV brightening events.

Key words: Sun: chromosphere–Sun: transition region–Sun: activity.

1. INTRODUCTION

EUV blinkers are intensity enhancements, primarily seen in transition region lines, which were detected in SOHO/CDS observations by Harrison (1997) and analysed in detail by Harrison et al. (1999), Brkovic, Solanki & Rüedi (2001), Parnell et al. (2002) and Bewsher et al. (2002, 2003). A current issue of interest is their relationship to other transient phenomena in the solar chromosphere, e.g. explosive events (Innes et al. 1997), and corona, e.g. network flares (Krucker et al. 1997). Furthermore, the relationship between blinker properties derived from different instruments using different observing sequences and techniques is under active investigation.

With the exception of Parnell et al. (2002) and Bewsher et al. (2003), most studies have been focused on quiet Sun blinkers and neither of those studies used high cadence observations such as those of Gallagher et al. (2000) in their investigation of short duration transition region brightenings. In addition, simultaneous observations in the EUV and Hα are rare and no Hα counterpart to the EUV blinker has yet been detected, although it has been proposed that blinkers may be related to spicules (see e.g. Madjarska & Doyle 2003). Here we report the detection of an Hα counterpart using simultaneous high cadence observations of active region NOAA10039/10044 from the SOHO Coronal Diagnostic Spectrometer (CDS) and the Hida Observatory Domeless Solar Telescope (DST). We study the properties of short duration active region EUV brightenings, to confirm that they would be classified as blinkers, and examine their spatial and temporal relationship with the Hα features in detail.

In addition, Chae et al. (2000) proposed from CDS and SUMER data that EUV blinkers are in fact composed of small-scale brightenings of a few arcsecs in
size and lasting a few minutes. We also use our high cadence observations to re-examine this issue.

2. DST/CDS CAMPAIGN

In July and August 2002 we performed coordinated high cadence EUV and Hα observations of active region NOAA10039/10044 using SOHO/CDS and HIDA/DST. The objectives were to study the relationship between EUV brightenings and Hα features in detail, and to make a statistical study of EUV blinkers using long duration observations at multi-wavelengths with as high a temporal cadence as possible while retaining some imaging capability to combine with the spectroscopic information. Thus we made CDS observations in the He I 584.3Å, O V 629.7Å and Mg IX 368.0Å lines formed at temperatures of logT=4.55, 5.35 and 6.0, respectively, with an exposure time of ~5s and a spatial resolution of 4" x 3.2". The CDS Field-Of-View was 16" x 240" with occasional scans of 48" x 240" to aid coalignment with the DST images. We also observed in the Hα line centre and +/-.05Å wings with an observational cadence of a few seconds and a spatial resolution of about 1" (depending on seeing conditions). Fig. 1 shows an Hα line centre image of NOAA10039/10044 with the CDS FOV overlaid (solid line - wide FOV, dotted line - narrow FOV).

3. SHORT DURATION BLINKERS

Numerous short duration (<3 mins.) brightenings were observed simultaneously in the O V and He I lines between 22:00UT on July 26 and 05:00UT on July 27. These brightenings showed intensity increases of factors 1.1-3.0 & 1.1-1.8 in the O V and He I lines, respectively, which are within the typical range of values quoted for longer duration quiet and active region blinkers by Bewsher et al. (2002) & Parnell et al. (2002). Such short duration brightenings have previously been reported in the quiet Sun by Gallagher et al. (2000) and are thought to be members of the short duration tail of the blinker distribution reported by Harrison et al. (1999). Harrison et al. (1999) were unable to detect such short duration events due to the cadence of their observations and this is the first time they have been reported in active regions. We examined the simultaneous Hα observations to search for an Hα counterpart to these events.

Figs. 2 & 3 shows two examples of what appears to be a simultaneous detection of a brightening in Hα. Fig. 2 shows an event at around 1:27:15UT and Fig. 3 shows and event at around 1:52:09UT. In both figures the top row shows He I images from the narrow field of view observations by CDS, the middle row shows O V images from CDS and the lower row shows coaligned Hα images from the DST.

Note the small simultaneous brightenings in the He I and O V images. In Fig. 2 the brightenings are visible in the 1:26:31UT image, attain peak brightness at 1:27:14UT and have already disappeared a few minutes later at 1:30:11UT. In Fig. 3 the brightenings are visible at 1:50:00UT, attain peak brightness at 1:51:28UT and have almost disappeared by 1:52:11UT. Small circles identify these brightenings and also the Hα counterparts in the lower row. In Fig. 1 the Hα counterpart is visible in the 1:26:42UT image and it has already faded by 1:32:21UT. In Fig. 2 the Hα counterpart is visible in the 1:50:59UT image and it has already faded by 1:53:07UT.

4. SPATIAL RELATIONSHIP

Since He I and Hα are formed in the upper and lower chromosphere, respectively, these were used for a detailed coalignment. Generally there were sufficient large scale features in both wavelengths to attain high accuracy. The coaligned images were further registered with the CDS narrow FOV for greater precision. The procedure is described by Brooks et al. (2004).

Figs. 4 & 5 show the results of the coalignment for the two events. In both figures the CDS He I image is shown in the upper left panel and the DST Hα image in the upper right panel. The lower left panel shows the He I image with an Hα image contour overlay and the lower right panel shows the Hα image with a He I contour overlay. In Fig. 4 the He I image was taken at 1:27:14UT and the Hα image at 1:27:05UT. In Fig. 5 the He I image was taken at 1:51:28UT and the Hα image at 1:52:09UT. The He I contour levels are ~80% of the max. intensity
Figure 2. Example of a short duration EUV blinker and co-spatial brightening in Hα. Top row: He I images, Middle row: O V images, Bottom row: Hα images. The times are shown and the brightenings are circled. The vertical lines on the Hα images show the CDS slit position.

Figure 4. Co-aligned He I and Hα images confirming the spatial coincidence of the EUV blinker and the Hα counterpart for event 1. Top left: He I image at 1:27:14UT, Top right: Hα image at 1:27:05UT, Bottom left: Hα contour over He I image, Bottom right: He I contour over Hα image. Note the spatial coincidence of the features at around position (17,64).

Figure 3. Second example of a short duration EUV blinker and co-spatial brightening in Hα. Top row: He I images, Middle row: O V images, Bottom row: Hα images. The times are shown and the brightenings are circled. The vertical lines on the Hα images show the CDS slit position.

Figure 5. Co-aligned He I and Hα images confirming the spatial coincidence of the EUV blinker and the Hα counterpart for event 2. Top left: He I image at 1:51:28UT, Top right: Hα image at 1:52:09UT, Bottom left: Hα contour over He I image, Bottom right: He I contour over Hα image. Note the spatial coincidence of the features at around position (16,65).
and the Hα contour levels are ~70% of the max.
intensity. It can be seen that the Hα contours en-
circle the He I brightenings and vice-versa for both
events. Thus the Hα brightenings are co-spatial with
the EUV blinkers.

5. INTENSITY, VELOCITY & WIDTH
EVOLUTION

Figs. 6 & 7 show the intensity evolution in each
wavelength and the relative velocity and excess 1/e
width changes in the He I and O V lines for both
events. The velocity and width results have been
determined from a detailed correction of dependen-
cies on instrumental effects, such as the line tilt on
the detector, using a similar scheme to independently
derived methods such as Bewsher et al. (2002) and
Stucki et al. (2003)."
6. EFFECTS OF SPATIAL/TEMPORAL RESOLUTION

Chae et al. (2000) found that blinkers with characteristics close to their mean properties (15 mins.) consist of small-scale brightenings observed by SUMER. We found from our high cadence observations that even the short duration blinkers studied here are composed of elementary brightening events. For example, Fig. 8 shows He I light curves in different pixels and combinations of pixels within solar-X pixels 5 and 6 and solar-Y pixels 17 to 21. The curves are shown for a twenty minute period around the time of the first event studied here. The left panel shows the variation in total intensity for all 10 pixels [denoted (5:6:17:21)] and curves for totals along each solar-Y column [denoted (5,17:21) and (6,17:21)]. The central panel then shows the intensity variation for individual pixels 17 to 21 in column 5 and the right panel shows the intensity variation for individual pixels 17 to 21 in column 6.

Note that the first event at 01:27UT in He I appears to consist of 2-3 separate 2-3 minute brightenings if we consider only the individual pixels, see e.g. pixel (6,21) which shows two brightenings at around 01:27 and 01:32UT. However, these separate individual brightenings appear almost as one event in the totalled curves (of each column or all pixels). These curves show an initial increase at 01:23UT, two separate peaks at 01:27 & 01:31, and do not show a decrease to below the pre-event average until 01:36. This implies a duration of about 13 mins. (close to the average for blinkers reported by previous authors) if the event is treated as one. Thus the individual brightenings are difficult to distinguish, especially with automatic detection methods. Note also that the peaks in this case are within 3.5 minutes. Therefore, observations with a lower cadence would not detect these as separate events. This is illustrated in Fig. 9 which shows the same light curves but degraded to a time resolution of 309s. The separate peaks are not noticeable in the total curve, nor even in the individual pixels (see e.g. the light curve for pixel (6,21) which previously showed two very obvious peaks).

7. SUMMARY

We have studied short duration active region blinkers simultaneously in the EUV and Hα for the first time using data from a coordinated campaign between SOHO/CDS and HIDA/DST. We presented two examples where an Hα counterpart to the EUV blinker was detected nearly simultaneously in the same spatial location for the first time. This finding suggests that blinkers can result in intensity increases over a much wider range of temperature than previously considered. Both the examples studied show significant excess line broadening (>15 km s⁻¹) at the peak of the event, and the second example showed evidence of downward motion. These results are in

Figure 8. Light curves for He I totalled over different areas within pixels 5-6 (solar-X) and 17-21 (solar-Y). The curves are for each individual pixel, totals over the X-columns [denoted (5,17:21)], and totals over all the pixels [denoted (5:6,17:21)].

Figure 9. The same He I light curves as Fig. 8 but degraded to a temporal cadence of ~309s.
agreement with those for longer duration blinkers previously reported by Madjarska & Doyle (2003) and Bewsher et al. (2003).

The high cadence of our observations also allowed us to confirm the result of Chae et al. (2000) that blinkers may be composed of small-scale short-duration brightenings. Using CDS alone, we extended this analysis to shorter duration blinkers and found that they are composed of elementary short brightening events. In our two cases the Hα brightenings show much smaller intensity increases than are seen in the EUV, but they appear to correlate well with the elementary blinkers. The spatial- and temporal-relationships between the brightenings indicate a causal link between the EUV and Hα "blinker".

Finally, we conclude that the instrumental spatial and temporal resolution can combine to distort the characteristics of the short duration blinkers, and that separate events become indistinguishable if the observational cadence is not sufficiently high. Therefore, high cadence observations are required to accurately determine their properties.

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