A SEARCH FOR "BLACK-LIGHT FLARES"

L. v. Driel-Gesztelyi [1], H. S. Hudson [2], B. Anwar [3,4] , and E. Hiei [5]

[1] *Kiso Observatory, Institute of Astronomy, University of Tokyo, Japan*
[2] *Institute for Astronomy, University of Hawaii, U.S.A.*
[3] *Kwasan and Hida Observatories, University of Kyoto, Japan*
[4] *National Institute of Aeronautics and Space, Bandung, Indonesia*
[5] *National Astronomical Observatory of Japan, Tokyo, Japan*

Extended Abstract

Calculations which predict that a phenomenon analogous to the stellar negative pre-flare could also exist on the Sun were published by Hénoux *et al.* (1990), and Aboudarham *et al.*, (1990), who showed that at the beginning of a solar white-light flare (WLF) event an electron beam can cause a transient darkening before the WLF emission starts, under certain conditions. They named this event a "black light flare" (BLF). Such a BLF event should appear as diffuse dark patches lasting for about 20 seconds preceding the WLF emission, which would coincide with intense and impulsive hard X-ray bursts. The BLF location would be at (or in the vicinity of) the forthcoming bright patches. Their predicted contrast depends on the position of the flare on the solar disc and on the wavelength band of the observation.

The *Yohkoh* satellite provided white-light data from the aspect camera of the SXT instrument(Tsuneta *et al.*, 1991), at 431 nm and with a typical image interval of 10-12s. We have used the *Yohkoh* white-light data, the first obtained form outside the Earth's atmosphere, to study white-light flares and in particular, to search for the predicted "black-light flares".

We have analyzed nine white-light flares observed by *Yohkoh* (Table 1) making very flat difference images, by using time-wise cancellation (Uchida and Hudson, 1971) to reduce the effects of the background brightness variations.

In most cases we did not find any sign of per-flare darkening. The white-light intensity increased practically simultaneously with the hard X-ray emission(also observed by *Yohkoh*; see Hudson *et al.*, 1992). There was one flare which showed some tendency for per-flare dips: the first "spotless" WLF of 26 Jan. 1992 (Hudson *et al.*, 1994). It was an X-class flare and it was observed close to the limb (Figs. 1 and 2). Light curves for individual pixels in the most northerly (No. 5, cf. Fig. 1 - full line) and southerly (No. 6 - dashed line) show that the (negative) contrast exceeds 10%, compared with an rms fluctuation of about 5% and a peak excess (WLF) signal of about 50%. Incidentally, the separation of these two footpoints was at least 10^5 km, and the simultaneity of the two footpoints was closer than about 6 s (half the image interval); this implies an exciter speed in excess of 2×10^4 km/sec, explicable most easily with non-thermal electron energy transport. The hard X-ray light curve (22.7-32.7 keV) shown in Figure 2 (lowest curve) is for the entire flare; the bulk of the hard X-ray emission is associated with other white-light flare patches in the region (cf. Fig. 1).

Table 1. List of *Yohkoh* white-light flares

YYMMDD	Begin UT	Max UT	End UT	X ray Class	Opt Imp	Location	NOAA Reg.	Radio Flux (15.4)
911024	2224	2241	2251	M9.8	1N	S12E46	6891	340
911027	0537	0548	0712	X6.1	3B	S13E15	6891	13000
911110	2004	2013	2033	M7.9	1N	S15E43	6919	1500
911115	2233	2239	2254	X1.5	3B	S13W19	6919	1900
911203	1631	1639	1724	X2.2	2B	N17E72	6952	2300
920126	1521	1533	1606	X1.0	3B	S16W66	7012	650
920214	2304	2310	2342	M7.0	2B	S13E02	7056	2800
920708	0942	0950	1026	X1.2	1B	S11E46	7220	4200
920716	1653	1700	1712	M6.8	2B	S10W61	7222	690

Although Figure 1 and 2 are suggestive, we prefer to describe it in the words of Carrington (1859): "one swallow dose not make a summer". The search continues as we develop better data-analysis tools and examine additional flares. Why have we not succeeded so far? Assuming the correctness of the theory, we suggest the following observational limitations:

(i) The data do not have high enough time resolution (typically 10-12 sec) to detect such brief event.

(ii) The data do not have high enough spatial resolution (the *Yohkoh* aperture is 5 cm diameter, the pixel size 2.46 arc sec).

(iii) Other limiting noise sources exist: uncorrectable pointing jitter that converts spatial patterns into time-series noise, and there is also background solar variability (*e.g.* p-modes). We note that the noise levels in the Figures, as inferred from the point-to-point fluctuation, greatly exceed the counting statistics, so that these systematic noise sources, (*e.g.* the pmodes), dominate the search.

(iv) The *Yohkoh* flare trigger, which initiates the high time resolution, may occur late enough in the flare that pre-heating has occurred. According to the theory, this can quench the black-light flare phenomenon.

(v) In particular, the events observed by *Yohkoh* were not among the most energetic flares (the X6.1 of 27 October 1991 flare was poorly observed by *Yohkoh* from the point of view of data coverage. Rapid sampling only started when the flare was already in progress).

This study, although the best survey to date, was not ideal from the observational point of view. We therefore encourage further searches. Successful observations of this phenomenon on the Sun would greatly strengthen our knowledge of the lower solar atmosphere and its effects on solar luminosity variations.

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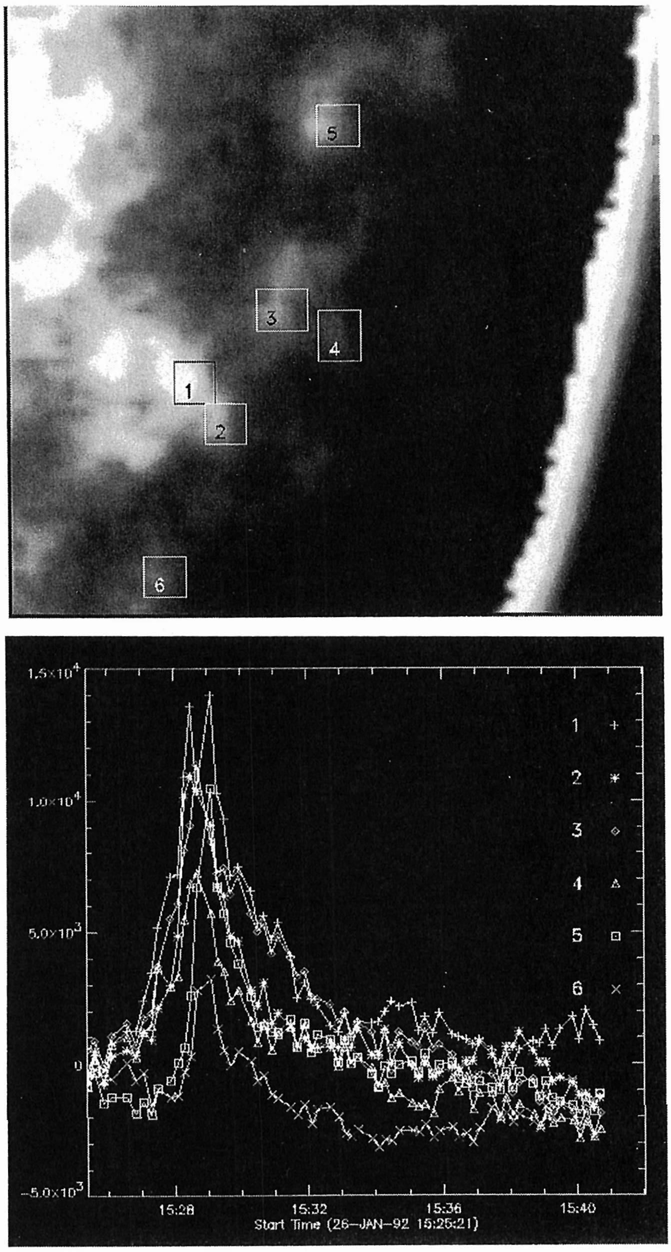

Fig. 1. The *Yohkoh* "spotless" white-light flare of 26 Jan. 1992. SXT aspect camera image identifying the patches (upper panel) and their light curves. The latter exhibit impulsive features that coincide precisely with different spikes of the hard X-ray burst (see Fig. 2), and the suggestion of a BLF effect in patches 5 and 6.

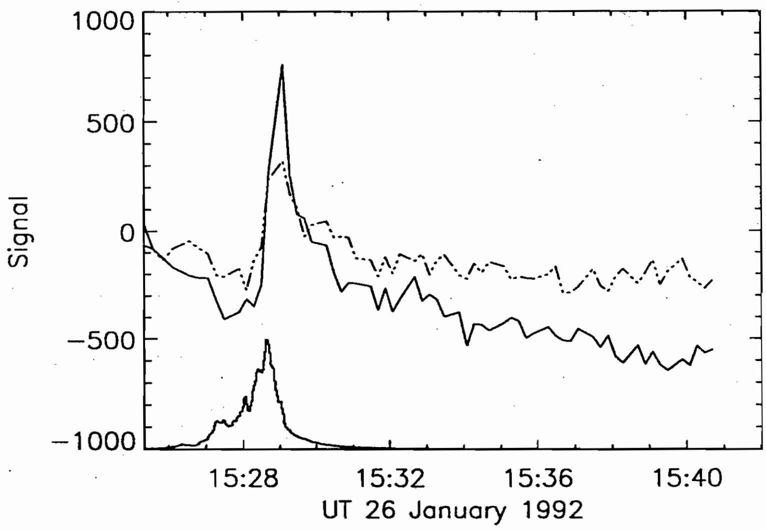

Fig. 2. Light curves for individual pixels in the northernmost (No. 5, cf. Fig. 1 - full line) and southernmost (No. 6 - dashed line) footpoints of the "spotless" white-light flare of 26 Jan. 1992. The N footpoint is the clearest case we have seen of a possible negative signature, and matches reasonably well with the theory.

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