SOME OBSERVATIONAL RESULTS ON ELLERMAN BOMBS

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1. Introduction

Ellerman bombs and moustaches are identical phenomena (McMath et al., 1960). They are characterized by the spectrum of very thin and extended emission wings emerging from strong Fraunhofer lines as R. Kitai showed in the last speech. Though some flares, especially flare kernels, show a moustache-type spectrum, the majority of Ellerman bombs are flare independent (McMath et al., 1960; Bruzek, 1972). Bruzek (1972) found a close correlation between Ellerman bombs and continuum facular granules. Roy and Leparskas (1973) pointed out that 86 % of the bombs in an active region near the limb and 56 % in the disk-center region were seen to be accompanied by ejection of dark material. Kitai and Kawaguchi (1975) showed that the Ellerman bombs occur at the locations where the sign of the line of sight velocity changes. This investigation is based on the filtergrams of two active regions just near the solar limb obtained with a Hα Lyot filter of Domeless Solar Telescope at Hida Observatory. One active region is McMath region 16224 observed from 221654 UT on 13th to 070506 UT on 14th and from 222156 to 233129 UT on 14th Augast 1979. The central wavelength of the filter passband was changed from Hα center to Hα ± 0.4, ± 0.8, ±1.2, ± 1.6, ± 2.0 and ± 5.0 in order. Some frames of these filtergrams are of good quality and enable us to study the shape and size of Ellerman bombs very close to the solar limb (section 2). The other active region is McMath region 16867 observed from 215134 to 232320 UT on 5 June 1980. For this active region we took a photograph every five seconds on the average at the fixed central wavelength of Hα - 1.2 Å where the bombs show the greatest contrast against the surrounding solar features. This sequential observation of high time resolution enables us to study the life time and the photometric light curve of Ellerman bombs (section 3).

2. Shape and Size

Bruzek (1972) pointed out that moustaches appear as irregular-shaped features (spikes, mounds) at the very limb of the sun. On our filtergrams of two active regions near the solar limb in this study, most Ellerman bombs can be seen as an elongated shape or a spike. In order to clarify this quantitatively, we measured the widths and lengths of 214 bombs in 11 filtergrams which are listed in Table 1.

TABLE 1

Ellerman bombs measured

Date	8/13 1979	8/13 1979	8/13 1979	8/13 1979	8/13 1979	8/14 1979	8/14 1979	8/14 1979	6/5 1980	6/5 1980	6/5 1980
Time of observation (UT)	2222	2225	2232	2321	2333	0004	0009	2224	2225	2248	2255
Wavelength shift from Hα ceneter	-2.0	-2.0	-2.0	+1.6	+0.8	-1.6	-5.0	-1.2	-1.2	-1.2	-1.2
Position of active region	S 28 E 80	S 28 E 80	S 28 E 80	S 28 E 79	S 28 E 79	S 28 E 79	S 28 E 79	S 28 E 66	S 10 W 78	S 10 W 78	S 10 W 78
Number of bombs measured	12	16	13	18	8	27	16	22	21	30	31

We used nearly the same methods as Bruzek (1972) : (a) the widths and lengths were measured directly on the negatives (1" = 156μ) with a Nikon measure scope, (b) they were measured on the projected negatives providing a scale 1" = 3 mm, and (c) photometric intensity profiles were determined for 30 typical bombs and the full half width of the profile was considered the width or length of the bombs. the results derived from the methods (a) and (b) agreed well each other. Systematic differences were found, however, between (a) and (c). Then we derived a simple empirical formula to reduce the results by the method (a) to the full half widths of the photometric profile. The results are presented in the form of histograms in Figure 1. Since the lengths of the bombs in Hα - 5 Å are distinctively shorter than those in other wavelengths, we excluded the lengths in Hα - 5 Å from Figure 1. The bombs of 2224 UT Aug. 14 were also excluded from the histogram of lengths because of their smaller heliographic longitude. According to Figure 1, 37 % of bombs have the width less than 0.4 second of arc. Moreover, it appears that even larger bombs are often consisted of two or more smaller spikes, on which we will discuss further in section 3. After all a typical width of a bomb spike is probably less than 0.4 second of arc. The result we have obtained is less than those found by Bruzek (1972) (0".5 - 1".0); this is probably due to the better resolution of our observations. The distribution of apparent lengths is nearly symmetrical around the peak number and most of these lengths clearly exceed the resolution of our photographs. We can therefore obtain 1".1 as a significant mean apparent length of a bomb spike. Due to the foreshortening effect, these apparent values give only a minimum of the real length.

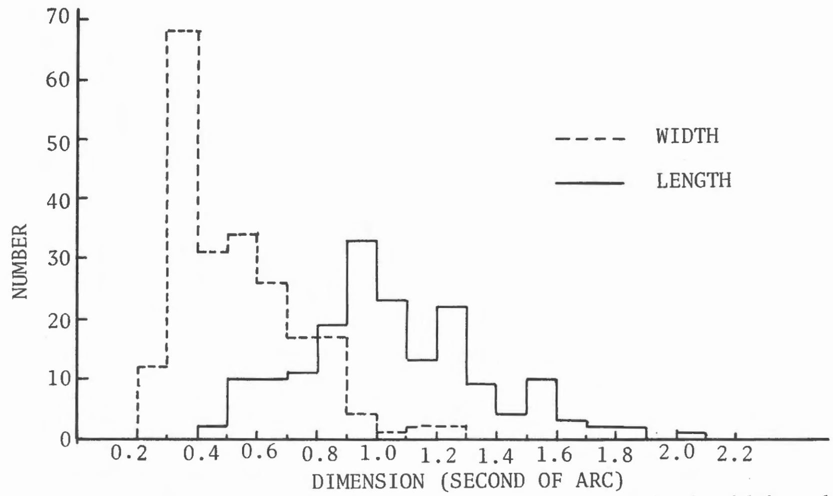

Fig.1 Histograms showing the distribution of bomb width and length.

3. Lifetime and Light Curve

From 2151 to 2323 UT on 5 June 1980, 921 frames of filtergrams in Hα -1.2 Å were obtained at nearly constant time rate for McMath region 16867 (S 10, W 78). We selected 101 bombs in this active region and estimated their lifetimes by tracing them on successive frames of negatives. The lifetime of a bomb was defined as the duration between the start of brightening and complete dimming into surrounding brightness. The results are presented in the form of a block diagram in Figure 2.

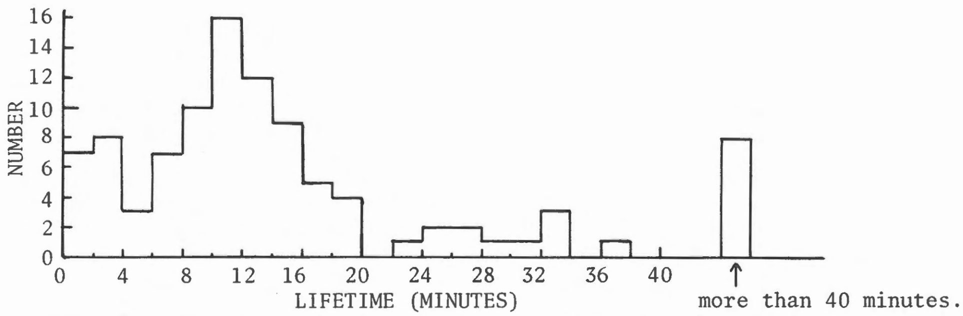

Fig. 2 Histogram showing the distribution of bomb lifetime.

In this figure, 7 bombs of (0-2)-minutes' lifetime and 3 of (2-4)-minutes' are corresponding to the foot points of impulsive surge activities at the same location. These 10 bombs were excluded from the calculation of the mean lifetime because of their flare-like feature. The all bombs with lifetime longer than 28 minutes in Figure 2 were found to pulsate from one to sevral times before disappearing. Excluding also these bombs from the calculation, We obtained 12 minutes as a mean lifetime of typical Ellerman bombs. This result is in a good agreement with that found by Roy and Leparskas (1973) (11 min), but much smaller than found by Bruzek (1972) (15 - 38 min). In order to study a life of a typical Ellerman bomb in more detail, we derived the photometric light curves for 9 typical bombs. Five of them are shown in Figure 3.

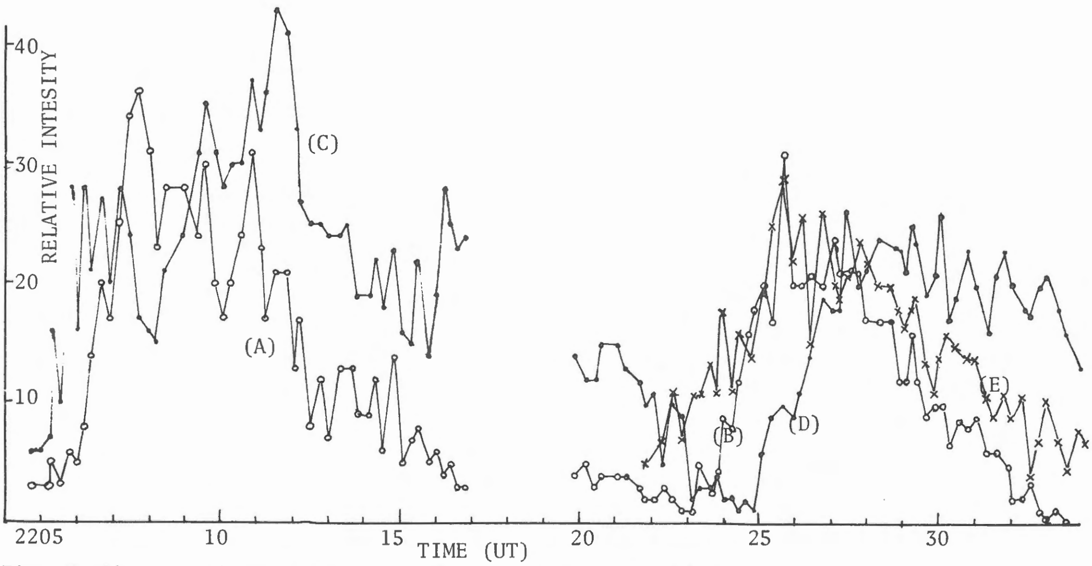

Fig. 3 Photometric light curves of typical Ellerman bombs.

From these light curves of 9 bombs we can obtain the average time scales for brightening and decaying: the first maximum brightness is attained in about 2.2 ± 0.4 minutes, then nearly the same brightness is kept for about 4.7 ± 1.0 minutes, and the decaying is completed in about 4.9 ± 1.3 minutes on the average. In Figure 3, the bombs (A) and (B) brightened in the same location and the bomb (D) occured at the same point as (C). Such a recurrence seems to be a rather common characteristic of Ellerman bombs as pointed out by McMath et al. (1960). We confirmed that 45 % of bombs recurred during our observation on 5 June 1980. The bomb (C) pulsates two or three times before dimming at 2223 UT. The pulsation of brightness also seems to be distinctive feature for large and bright bombs. This pulsation may be due to the fine structures inside a large bomb which brightens and dims one after another.

References

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