FLOWS, FLARES, AND FORMATION OF UMBRAE AND LIGHT BRIDGES IN BBSO REGION No. 1167

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Abstract. We present high-resolution observations of the large active region BBSO No. 1167 (Boulder No. 5060) which cast new light on the structure of sunspot regions. We obtained excellent data, highlighted by videomagnetograms (VMG) obtained with our 65-cm telescope, which give unprecedented spatial resolution, about 0.5″ for much of two 11-hr periods. This permitted us to see details of the field evolution and flows in the AR. The Hα filtergrams and D3 filtergrams permit study of these magnetic changes compared to spots and chromospheric structure.

The region was a huge but simple active region (CMP July 2, 1988) in which we observed rapid flux emergence for several days. Because the new flux generally matched the old, there were few large flares. However, there were 14 flares on June 28 and 29, mostly in two sites. The first site was a δ spot which already existed when the active region appeared on the east limb. This site showed little change of magnetic structure during our observing period. The second site is an area disturbed by new flux emergence, which included a δ spot which formed and disappeared in two days, and a rapidly moving p spot. Flares occurring at one site almost always produced footpoints at the other. The delay between flash phases of the same flare at the two sites ranges from 40 to 160 s.

The magnetograms show complex fine structure, with some closely intertwined regions of opposite polarity. In a region of new flux emergence, positive (leading polarity) flux flows along elongated channels immersed in the negative flux. Moving magnetic features occur around all of the spots.

We point out other interesting aspects of this large region: (1) While there is extensive penumbra around the main umbrae, there is also significant penumbra apparently unrelated to any spot. These unusual penumbrae are either due to flux returning to the surface, flux left behind by the moving umbra, or associated with pores that appear and disappear. (2) We observed umbrae to move faster than the accompanying penumbrae, and concluded that penumbrae are not a simple extension of the umbra. (3) We found that combining spots of the same polarity do not completely merge, but are always separated by a thin light bridge. This means that the emerging flux loops are discrete entities.

1. Introduction

The huge active region BBSO No. 1167 appeared on the east limb on June 24, 1988 and was followed by us until July 5 under generally good conditions. A fairly complete data set was obtained at Big Bear Solar Observatory (BBSO) on this region. The development of the region from June 27 to July 2 can be seen in Figure 1.

When first photographed on June 25 the region had only the big p spot p1 and a cluster of f spots, but on June 26 several EFR’s emerged on the upper (N) side, and Figure 1 shows how their rapid westward motion led to their merging into a second large p spot which moved ahead of p1 to the upper right corner in Figure 1. Despite its size (3 × 10⁻³ of the hemisphere) the overall magnetic structure of the region was simple and it had few flares. During the peak of the flux emergence there was modest flare activity on June 28 and 29 associated with the formation and disappearance of a δ spot and an anomalous leader spot. In this paper we have concentrated on:

Fig. 1. D3 images for June 27–July 2, 1988, showing the evolution of the group. Sunspots are marked either $p$ or $f$ according to their polarities. All pictures are N top, W right. The facular brightness is somewhat reduced in this line by overlying absorption.

(1) Morphology changes and flows of sunspots and magnetic structures.
(2) Properties of growing spots.
(3) δ spots.
(4) The location and occurrence of flares.

The combination of high time and spatial resolution observations with a big sunspot gives an exceptional chance to study these problems. By rapid projection of re-registered digital images we could detect small flows and link them to their sources. Despite some claims to the contrary, all the larger scale motion of magnetic elements in an active region is due either to sunspot separation associated with flux emergence or to Evershed flow, including the outward flow of moving magnetic features (MMF) in the surrounding