TRANSIENT BRIGHTENINGS OF INTERCONNECTING LOOPS

II. Dynamics of the Brightened Loops

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(Received 19 August, 1980)

Abstract. We discuss three different kinds of dynamic events related to interconnecting loops observed in soft X-rays aboard Skylab. (1) A newly born transequatorial loop that was either emerging from subphotospheric layers or gradually filled in with hot plasma. (2) Large-scale twists of interconnecting loops which never relax, and often only form, after the loop brightenings. (3) Three events where the loop that later interconnected two active regions had been visible long before one of the interconnected regions was born. Several impacts this observation might have upon our understanding of the process of flux emergence are suggested.

1. Introduction

In an earlier paper (Švestka and Howard, 1979; referred to as Paper I) we studied the occurrence of sudden brightenings of interconnecting loops in relation to flares, newly emerging flux, and slowly moving disturbances from other active regions. We have also tried to estimate the lifetime of the brightenings and the density and temperature of the brightened loops. In this second paper, we want to discuss some dynamical effects associated with these brightenings:

(1) The process of birth of transequatorial loops;
(2) observed twists of interconnecting loops; and
(3) interconnecting loops that exist prior to the birth of one of the interconnected active regions.

2. The Process of Birth of Transequatorial Loops

As we mentioned in Paper I, we have been greatly interested in finding any dynamic effects propagating along the interconnecting loops which could indicate the nature of the process of the loop heating. However, with only one exception, no dynamic effects of this kind could be detected in any loop we studied, in spite of the fact that some loops were observed in the earliest phase of the brightening (cf. Section 4.1 in Paper I). This indicates that either the loops are heated homogeneously along their
whole extent (with some preference of the flare tops in the initial phase, cf. Paper I), or the heating propagates so fast that the Skylab data are unable to detect it.

The only exception was a transequatorial loop observed on September 2, 1973 (BF-5 according to the notation adopted in Paper I), where the brightening extended gradually from region McMath 12512 on the southern hemisphere (16° S) to McMath12510 (15° N), forming thus a newly visible interconnecting loop. The loop could not be seen at 16:18 on September 2, it began to be visible at 22:52 on that day, and it extended along the full distance of about 30° at 04:48 on September 3 (cf. Figure 1).

Fig. 1. Possibly the birth of a new transequatorial loop on September 2/3, 1973. The left picture, at 22:52 UT on September 2, shows the loop partly extending from the newly born McMath region 12512 (below) toward McMath 12510 (above). The right picture, at 04:48 on September 3, shows the connection fully established. The central frame was taken at 01:11 on September 3. This figure also shows the event AF-5 discussed in Section 4: The brightened X-ray bright point can be seen on the right-hand frame. (AS&E photographs in soft X-rays: 2–54 Å, exposure 16 s.)

An estimate of the speed of growth of the brightening is difficult and inaccurate for several reasons: (1) We do not know how deep in the regions the loop was rooted (see the extensive X-ray emission of the active regions in Figure 1). (2) The loop was fairly diffuse. (3) Gaps between successive pictures are large: 2.3 and 3.5 hr, respectively. The only result we can give is that prior to 22:52 on September 2 the mean speed was >11.6 km s⁻¹, but it decreased to only 3 to 6 km s⁻¹ between that time and 4:48 on September 3. This is a speed lower by two orders of magnitude than the sound speed or Alfvén speed for $n \sim 10^9$ cm⁻³ and $B \sim 10$ G.

We saw somewhat similar behaviour in the case of the transequatorial loop that connected McM 12474 and 12472 during its birth on August 4 to 6 (cf. Figure 2b in Švestka et al., 1977). Therefore, it is probable that this event of loop brightening also was a case of the birth of a transequatorial loop. In contrast to the August event, however, where the newly formed loop system stayed visible for at least two days (cf. event AF-3 in Paper I and here Section 3), the loop of November 2 disappeared again after 12:10 on September 3. It might have become visible once more for a few hours.