THE FILAMENT ERUPTION IN THE 3B FLARE OF JULY 29, 1973:
ONSET AND MAGNETIC FIELD CONFIGURATION

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We present direct observational evidence for the preflare magnetic field configuration, the nature of the filament destabilization and triggering of the flare, and the magnetic field configuration after the filament eruption in the large, well-ordered, expanding two-ribbon flare of July 29, 1973.

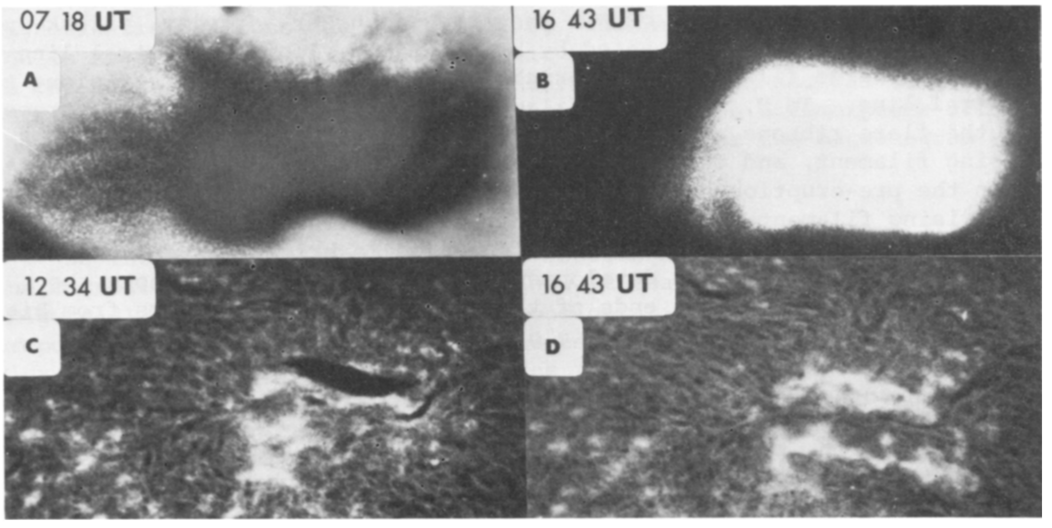


Fig. 1. Preflare (left) and late phase (right) coronal X-ray structure (top) and chromospheric Hα structure (bottom). A and C show that before eruption the large filament was enclosed in an arcade of coronal loops; B and D show that a similar, but brighter, arcade of hot flare loops, rooted in the separating Hα ribbons, was again present in the late phase. A,B,C,D are all of the same scale, orientation and area. A and B are from AS&E Skylab X-ray filtergrams of bandpass 2-32 Å plus 44-45 Å and of 16s exposure; A is a positive-negative photographic subtraction which enhances features of low contrast, such as individual loops in the arcade. C and D are Hα filtergrams from the NOAA observatory in Boulder, CO. In this and all subsequent Figures, east is up, north is to the right.



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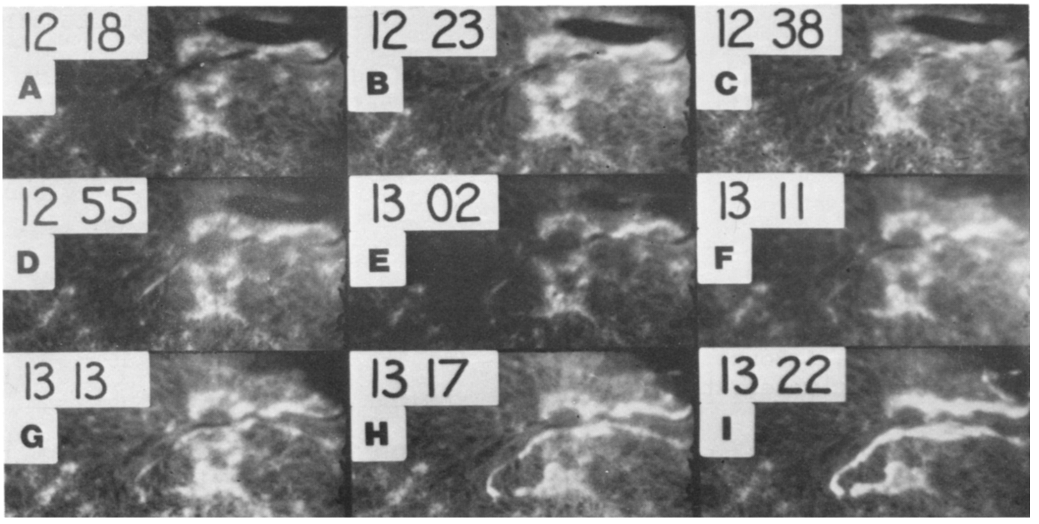


Fig. 2. Precursor activity, filament eruption, and onset and early development of the Hα flare ribbons. A, at about 45 min before flare onset, shows a narrow filament which ran along the neutral line and well below the large filament. B,C,D show the precursor activity: break-up of the low filament accompanied by brightenings along the neutral line below the large filament and a bright mass ejection to the left along the neutral line. In E, the large filament is erupting and the first traces of the flare ribbons are visible; these embryo ribbons are below the rising filament, and their distance from the neutral line is much less than the pre-eruption height of the bottom of the large filament. In F, the rising filament is higher and only faintly visible at the top edge of the frame, and the ribbons have increased in brightness and extent. G,H,I show the premaximum development of the flare ribbons; note the reverse curls on opposite ends of the two ribbons. Filtergrams from Big Bear Solar Observatory (BBSO) field station in Tel Aviv, Israel.

The observations show the following (Figures 1, 2 and 3). (1) Prior to the eruption, the filament was under an arcade of closed magnetic-field lines. (2) The magnetic field in the chromosphere and in the filament was strongly sheared across the neutral line. (3) The eruption of the filament and the onset of the two-ribbon Hα flare were preceded by precursor activity in the form of small Hα brightenings and mass motion along the neutral line and well below the bottom edge of the filament. (4) The onset of the flare ribbons occurred simultaneously with the filament eruption. (5) The initial distance of the Hα ribbons from the neutral line was much less than the height of the filament above the chromosphere. (6) The precursor Hα brightenings and the first brightenings in the flare ribbons were in the vicinity of the steepest magnetic field gradient in the flare region. (7) There was no evidence for emerging magnetic flux in the flare region.

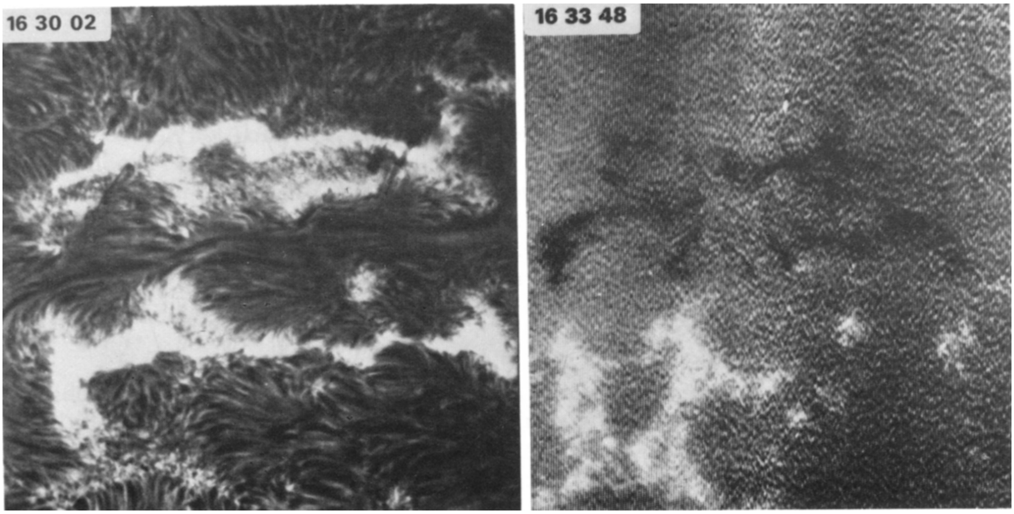


Fig. 3. High-resolution Hα filtergram (left) and videomagnetogram (right) taken in late phase at BBSO. Comparison with Figure 2 shows that the flare started in the vicinity of the steepest gradient in the magnetic field across the neutral line. The Hα fibril structure here and in Figure 2 shows that the magnetic field in the chromosphere and in the large filament was strongly sheared across the neutral line before the flare and was still highly sheared in the chromosphere after the filament erupted. Neither the Hα filtergram nor the magnetogram show any sign of emerging magnetic flux.

We interpret the above empirical results as follows with regard to the magnetic field configuration and how it changed in the flare (Figure 4). (1) The preflare field configuration was similar to that proposed by Heyvaerts et al. (1977), except that there was no emerging flux. The essential aspect is that the field near the neutral line and supporting the filament is strongly sheared, and the degree of shear decreases with distance from the neutral line, so that the strongly sheared field is enclosed in an envelope of loops which are much more nearly perpendicular to neutral line. (2) Both the destabilization of the filament and the initial flare ribbons resulted from magnetic field reconnection below the filament; this initial reconnection triggered the flare. (3) The reconnection began above the neutral line in the region of greatest shear in the magnetic field; a gradual increase in the shear to an untenable degree was the immediate cause of this flare, not the emergence of new magnetic flux as proposed by Heyvaerts et al. (1977). (4) Following the initial reconnection which started the filament eruption, the eruption set up the "inverted Y" configuration for the decay phase. Figure 4 shows how this transformation could occur in three dimensions and in accord with the observed chromospheric and coronal structure prior to and during the flare; cf Figure 1 of Hirayama (1974). The initial reconnection causes the filament to start

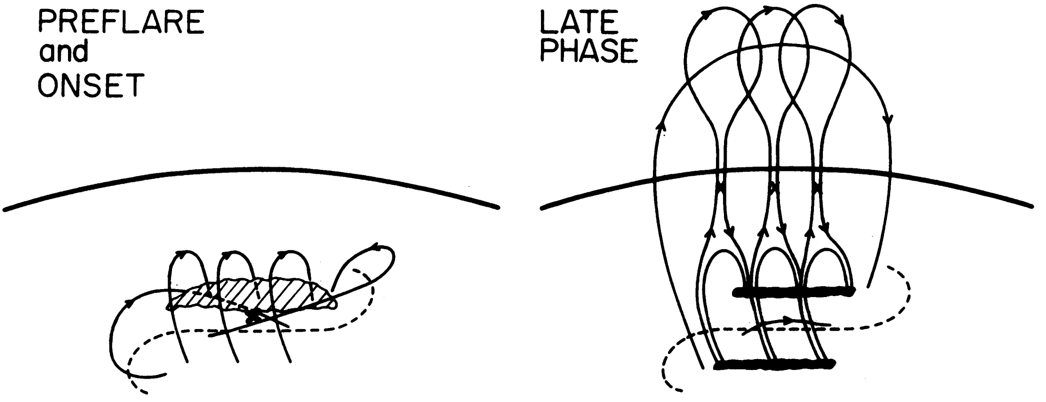


Fig. 4. Sketch of the inferred magnetic field configuration before and after the filament eruption. The heavy arc is the limb; the dashed line is the photospheric neutral line. Lines with arrowheads are magnetic field lines, and X's mark places where reconnection occurs. At flare onset and in the early phase, reconnection occurs under the filament between "closed" field lines having their remote ends in the curls (not shown here) of the flare ribbons. In the late phase, the reconnecting "open" field lines are rooted at the leading edges of the spreading ribbons. The upper reaches of the expelled field lines may be much higher in the decay phase than shown here.

to erupt, and from the start the change in the field configuration facilitates more reconnection below the rising filament, which leads to further expulsion of the filament, and so forth; the overall configuration is in this way unstable and thus produces the flare. In the late phase, the field lines which were initially closed over the filament and were "opened" by the eruption reclose by reconnection in the wake of the expelled filament.

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*DISCUSSION*

*Pallavicini:* I agree with your interpretation for this particular flare. However, this flare is a typical example of a class of flares, characterized by long-duration and long-decay time and associated with prominence eruptions and white-light transients. I do not think it is safe to extend the same interpretation to all flares.

*Moore:* Perhaps you are right. But, I think that this flare is more similar to most flares than you think. Many flares, perhaps most, begin with a filament eruption, or an outward eruption in the sheared field along the neutral line with no filament, at the onset of the two H$\alpha$ ribbons.

*Pneuman:* I think you touched on a very fundamental point here, which is: what comes first? Does the prominence lift, perhaps due to some internal instability allowing field lines to collapse and reconnect underneath - or, does the reconnection begin first and push the filament upward?

*Moore:* The evidence for this flare is that reconnection and the onset of the filament eruption are practically simultaneous. What comes first is the build-up of shear which leads to the onset of reconnection which is the same as the onset of the filament eruption.

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