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ABSTRACT

Observations and analysis of solar flare activated ascending "Fountain type" prominence of 1 February 1979 are presented. This "Fountain" prominence rose to 180,000 km above the solar surface and gave rise to a number of ascending loops and helical structure. These "helicals" are clear manifestation of magnetic field configuration. From these observations it is shown that, as the "Fountain" prominence rises, it carries along with it the complex magnetic field which unfolds as the prominence material expands into distinct magnetic field lines. Several type III radio bursts were also seen associated with this event. No type II or IV radio emission was reported.

1. INTRODUCTION

The observations of solar limb activities, such as active loop, eruptive prominences, and surges provide a good aid for studying the coronal transients and dynamics of plasma motion and associated radio emission. Recently, considerable interest has been shown for detailed study of these phenomena. Tandberg-Hanssen and Hansen (1973) have carried out an observing programme at Mauna Lao Observatory of HAO, to specially study in detail the ascending prominences through a wideband $H\alpha$ filter (10A half width) so that large Doppler shifted (~ 250 km/s) prominence features do not escape detection.

2. CINEMATOGRAPHIC $H\alpha$ OBSERVATIONS

Time-lapse $H\alpha$ solar observations are made through a 15 cm aperture telescope and a Halle 0.5A passband filter, from the island Solar Observatory at Udaipur. The normal rate for $H\alpha$ observations is generally kept to 1 to 2 per minute, but for fast moving energetic events the rate

of observations is increased to 10-12 frames per minute. 16 mm time-lapse movies are made from the original 35 mm pictures for studying the dynamics of solar phenomena.

2.1 1 February 1979 Ascending 'Fountain' Prominence

In McMath plage region 15808, which was behind the southeastern limb on 1 February 1979, an interesting ascending prominence or following Tandberg-Hanssen's et al., nomenclature - a "Fountain" prominence appeared between 0856-1036 UT. Initially at 0855 UT a bright spray appeared moving outwards at a small angle to the limb with a velocity of 88 km/s, and expanded into a loop structure A, shown in Figure 1. This closed loop A expanded at a rate of about 20 km/s and finally disintegrated into small bits-and-pieces within 10 minutes of its first appearance. During its journey through the corona, it retained the loop configuration.

Following this event a major flare behind the limb occurred at 0905 UT in the same region (Solar Geophysical Data, No. 415). Although this active region was almost 14° - 15° behind the limb on 1 February, an intense bright blob of material was seen appearing just above the limb around 0904 UT; this indicates that the flare might have been a major flare behind the limb as is further confirmed by enormous erupting prominence activity. The Solrad 11 data also indicate a strong enhancement of X-ray flux around 0905 UT.

Soon after the appearance of a bright 'blob' on the limb, another closed loop feature B (Figure 1, 0908 UT) started ascending with a velocity of about 100 km/s. Within 3 minutes, loop B developed into a complex 'helical' structure (Figure 1, 0913 UT). At first two distinct knots 1 and 2 forming a 'spiral' feature could be identified. As loop B rose to greater height, the structure opened up and two more knots on the 'helical' structure could be easily seen. A line tracing showing helical structure on the frame at 09.16 is shown in Figure 2. During the ascending motion of feature B, the 'spiral' configuration of the loops remained intact. Finally, as the 'spirals' expanded the knots became diffuse and were not seen (Figure 1, 0921 UT).

The feature C (Figure 1, 0913 UT) near the base of loop B ascended in a curvilinear path and soon (Figure 1, 0915 UT) formed into a well-defined helical structure moving with a velocity of nearly 75 km/s. Around 0921 UT (Figure 1) a vertically directed spray was noticed, emanating from the active region. This spray apparently lifted the prominence material to greater height (100,000 km) with much higher velocities on the order of 240 km/s.

Feature D (Figure 1, 0921 UT) appeared first as a bright knot on the tip of the "Fountain" which expanded into a distinct closed-loop structure at a rate of about 60 km/s. It appears that the vertically moving spray (Figure 1, 0921 UT) pushed the loop D to greater height and speed of nearly 150 km/s. Both features A and D expanded into a loop

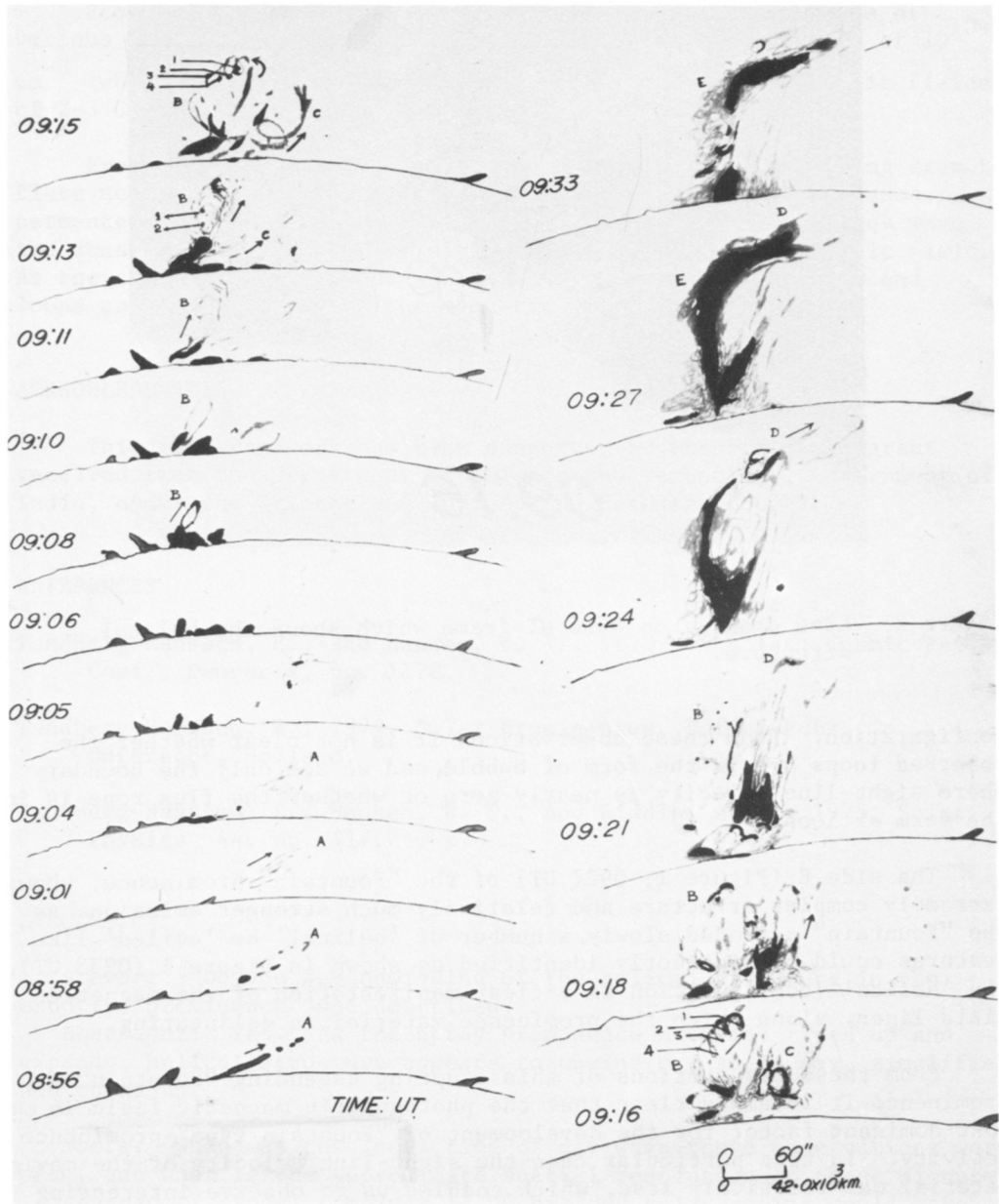


Figure 1. Line drawings of the 'Fountain' prominence of 1 February 1979. Frame times are in UT.

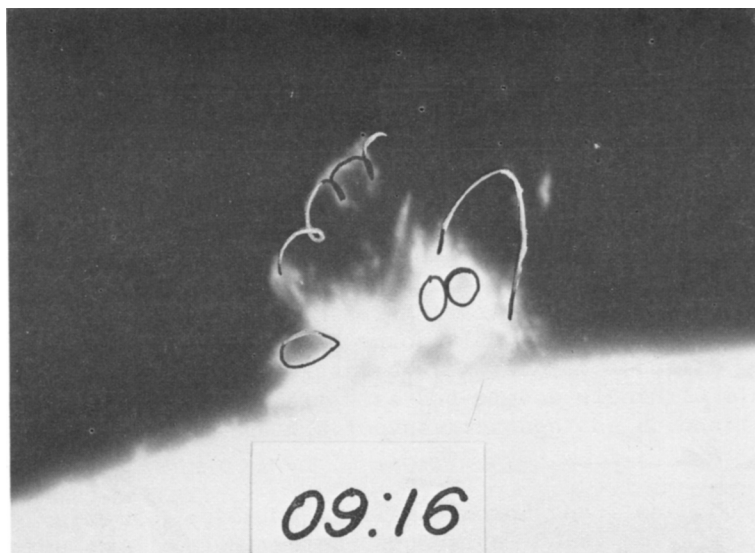


Figure 2. Line drawing on 0916 UT frame which shows the helical structure.

configuration. From these observations it is not clear whether the observed loops are in the form of bubble, and we see only the boundary where sight-line velocity is nearly zero or whether the flux rope is in the form of loop.

The side E (Figure 1, 0927 UT) of the "Fountain" prominence, shows extremely complex structure and relatively much stronger emission. As the "Fountain" ascended slowly, a number of 'helical' or 'coiled' like features could be distinctly identified as shown in Figure 1 (0933 UT). The 'helical' configuration is a clear manifestation of the magnetic field lines, along which the prominence material is delineating.

From these observations of this erupting ascending "Fountain" prominence it is amply clear that the photospheric magnetic field is the most dominant factor for the development of "Fountain type" prominence activity. In this particular case the sight-line velocity of the moving material was relatively less, which enabled us to observe interesting motions even through the narrow band $H\alpha$ filter (0.5Å). In this event we see clearly a number of cases wherein the prominence material is trapped and contained by magnetic field; this would perhaps indicate a near balance of kinetic and magnetic energy density, i.e.,

$$\frac{1}{2} \rho V^2 = \frac{B^2}{8\pi} . \quad (1)$$

From this equation the observed velocity of 100–200 km/s of various prominence features, and assuming the number density of 10^{10} cm^{-3} (which may not be correct) will be controlled by magnetic fields of 2–3 G.

From these observations, we notice that the plasma rising from the flare active region starts as bright and dense 'blobs' of plasma, permeated with complex magnetic field. Due to the flare–shock wave the dense plasma ascends rapidly carrying with it the magnetic field. As the spray plasma ascends and expands, the observed helical and loops open-up to manifest the magnetic field configuration.

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DISCUSSION

Stewart: Do you see unwinding of the helical structure in the eruptive prominence just described?

Bhatnagar: Yes. As the spray prominence material rises up and expands, helical structure appears to unwind or, so to say, simplifies and opens-up.

Moore: What was the local time of day when these observations were made, and what is the approximate spatial resolution of these pictures?

Bhatnagar: Local time was 14.00 hrs and solar seeing would have been 2" to 4" of arc.

Steinitz: Could the interpretation also be that subsequent magnetic loops are radiating and there is only an illusion of mass motion?

Bhatnagar: Of course, line of sight velocities have not been measured, but results from similar observations definitely show that these are actual mass motions in eruptive prominences.

Tandberg-Hanssen: (Reply to Steinitz) In similar prominences we observe Doppler shifts; hence, Bhatnagar et al.'s interpretation in terms of mass motions seems reasonable also in this case.