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On a peculiar type of prominence activation

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Abstract. We describe time-lapse H-alpha observations of a peculiar type of prominence activation of 1981 October 7 and its morphological behaviour. The prominence material seems to have originated from the photosphere as a huge twisted rope-like structure. It reached a height of $\simeq 10^5$ km, and later on split into braided closed loop-like features, which remained stable for a few minutes before breaking up at the top of the loop and finally fading out. The splitting of the twisted rope-like structure is explained on the basis of screw-type instability in current-carrying plasma column.

Key words : prominence activation—screw-type instability—twisted rope—plasma—flux tube

1. Introduction

Knots and filamentary or helical structures are common in active prominences (Ohman 1972; Rompolt 1975). Under favourable conditions fine structured knots of prominence material have been observed raining down from coronal heights along helical paths (Palus 1972; Tandberg-Hanssen *et al.* 1975; Bhatnagar *et al.* 1980). An interesting comparison of theory and observations has been made by Sakurai (1976). He regarded the filament as a magnetic flux-tube with sharp boundary. The onset of the motion of a filament which has been stationary until then is interpreted in terms of an instability of the same flux tube. For the eruption of the prominence, the most important factor in this instability is the winding or twisting of the filament, because this itself is the mechanism for energy injection (Raadu 1972; Hood & Priest 1979). The high resolution H-alpha photographs of active regions show twisted ropes of flux emerging from the photosphere and they tend toward instability as they rise and expand (Parker 1974).

In this paper we discuss the observations of an eruptive prominence. The filtergrams show evidence of twisting motion in the early stages of the eruption. There are only a few detailed descriptions of such motion (Jockers & Engvold 1975). The appearance of the prominence changed drastically over the period of observations.

2. Observations

On 1981 October 7 around 0210 UT the east solar limb showed a peculiar twisted rope structure, located near Hale-plage region 17899 at heliographic location E85 N21 (Solar Geophysical Data 1981). This prominence erupted like a huge rope emerging from the chromosphere and dragging material from the lower layers along with it into coronal heights. The observations of the event were made through a 15 cm, f/15 refractor using a 0.7 Å passband Halle H-alpha filter centred on the H-alpha line at 6563 Å. The observations comprise time-lapse photographs taken approximately every 5s and recorded on a Kodak SO-115 film using a 35 mm Robot recorder camera with an automatic arrangement to register the series of events. The Robot camera, coupled with sequential timer, is capable of registering the activity with a time resolution of 0.15s. The exposure time given was 1/60s.

3. Morphological description

Filtergrams in figure 1 have been drawn in figure 2. The height h of the highest portion of the prominence above the solar surface has been measured in the sky plane by making line drawings of the prominence after suitably enlarging the negatives (figure 2). The velocities of expansion (V_e) of the prominence material contained in the vertical plasma column (between points A and B in figure 2) have been determined. These points of h and V_e are plotted in figure 3. The universal time (UT) is given in the format : hours, minutes and seconds. In the subsequent morphological description of the event this time is referred to in both figures 1 and 2.

A close examination of the filtergrams shows that the eruptive prominence has two structural features in its early stages. Filtergram taken at $02^h15^m45^s$ UT (figures 1 and 2) shows that the structure, along the solar limb, has simply two braided strands and then a sharp 'kink' which is almost perpendicular to the solar limb (AB in figure 2), having a screw-type appearance and bright points along the vertical extension. It is this structure which later on split into fine threaded like features ($02^h20^m50^s$ UT). The maximum height attained by the prominence material above the solar surface is $\simeq 10^5$ km (figure 2; $20^h15^m55^s$) the material after splitting now seems to rain down and the appearance of loop formation is discernible ($02^h29^m50^s$ UT). Later on the falling mtaerial formed a fine braided loop ($02^h36^m30^s$ UT). The loops at this stage are much brighter than the earlier filtergrams (figure 1). Later filtergrams show the formation of some knot-like condensations at points ($02^h40^m32^s$ UT). This structure seems broken up at its top which is evident in the filtergram taken at $02^h44^m10^s$ UT. By $02^h48^m50^s$ UT the whole of the prominence material has faded out.

4. Interpretation

Alfven (1963) has shown that current above a certain strength bunches the magnetic field producing magnetic ropes. The rapid structural changes found in our observations may be due to the rising and expanding of a twisted rope that causes a rapid variation in the magnetic pattern in a newly forming active region (Parker

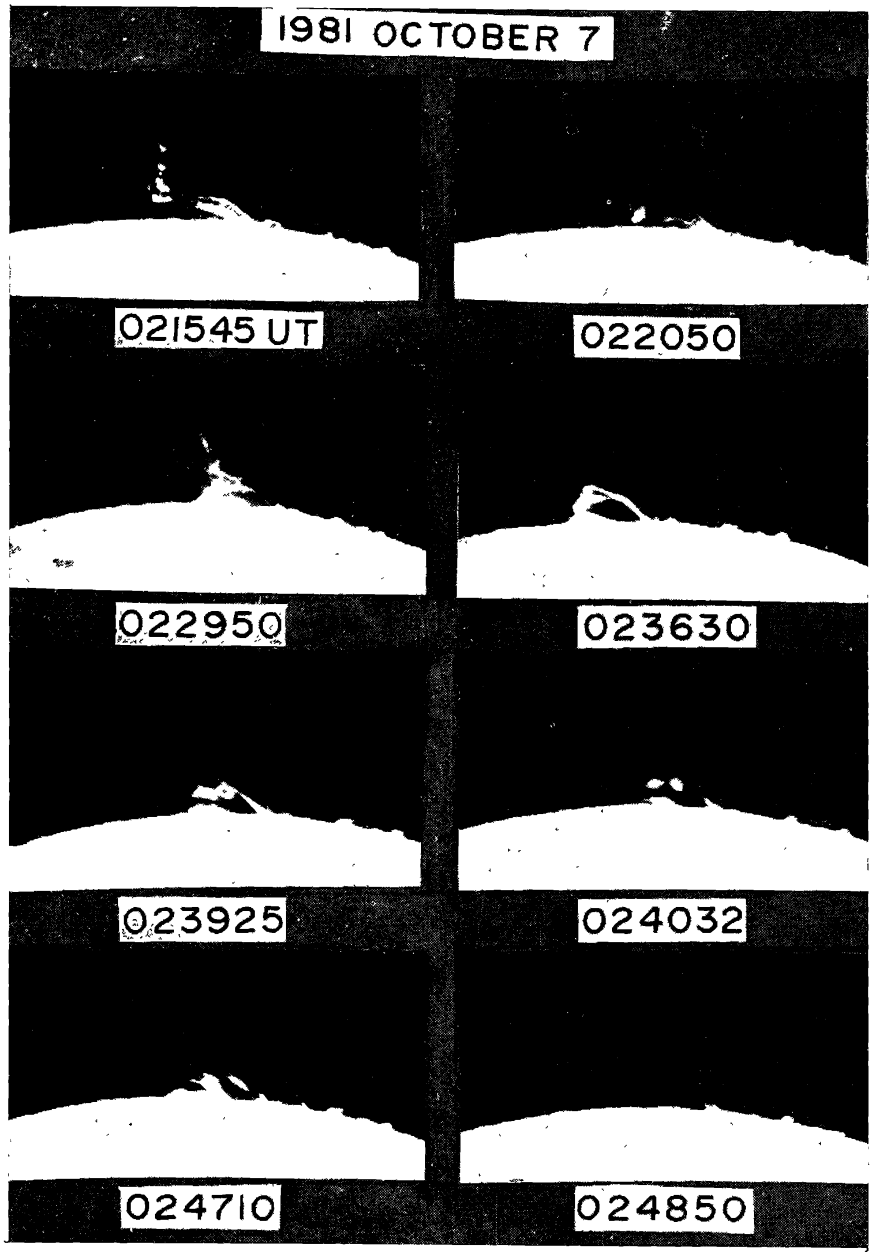

Figure 1. Some selected H-alpha filtergrams of the screw-type prominence at different moments.

1974). The splitting of the 'screw' can be explained on the basis of screw-type instability (Golant *et al.* 1980). This instability is attributed to the twist forces, which tend to straighten and shorten the magnetic lines of force.

In figure 1 ($02^h15^m45^s$) the vertical plasma column of the prominence stands against gravity. The plasma contained in this column can be confined not only by an external field but also by a field induced by a current passing through it. The twisting into a helix is attributed to the current-carrying plasma column. The expansion and straightening of the twisted structure can best be explained as due to the attraction of currents in the adjacent turns, which transform the helical column into cylindrical structure ($02^h20^m50^s$). At this stage the magnetic field energy is at

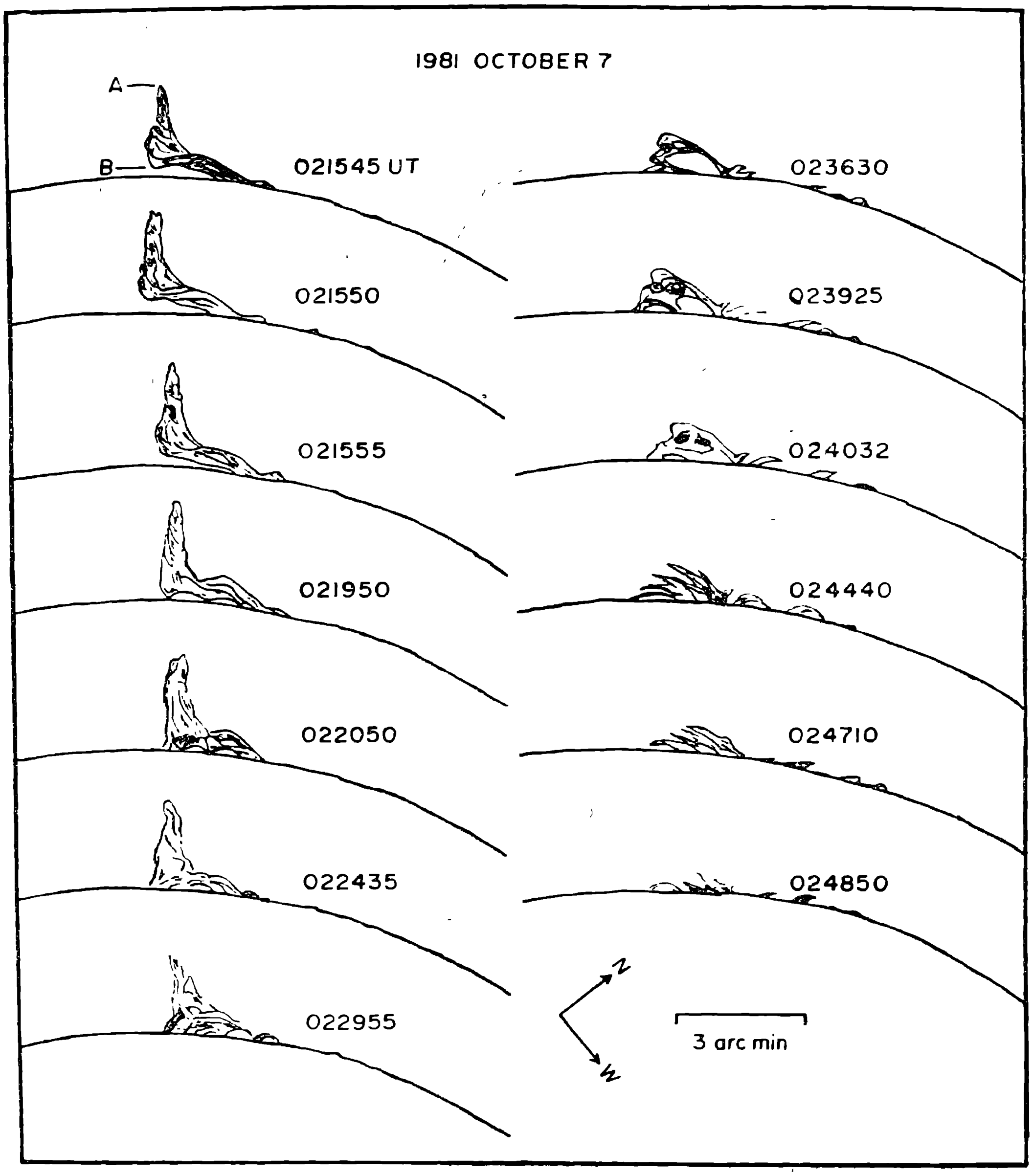

Figure 2. Line drawings of the event.

a minimum which is unable to hold the mass of the vertical column of the prominence material.

The formation of loops ($02^h29^m50^s$) might manifest itself in a slow reconnection of the magnetic field lines (Kopp & Pneuman 1976; Engvold 1980) and capture of the prominence material by the transverse magnetic field of the loops (Kleczek 1969). In this process the liberated potential energy of the helical column drains down the magnetic lines of force, which brighten up the loops (Hyder 1967a, b). The first sign of breaking up of the closed loops was seen around $02^h44^m40^s$ (figure 2). This might be attributed to the twisting of their footpoints which leads to a breaking of the closed flux tube at their top (Pant & Bondal 1983).

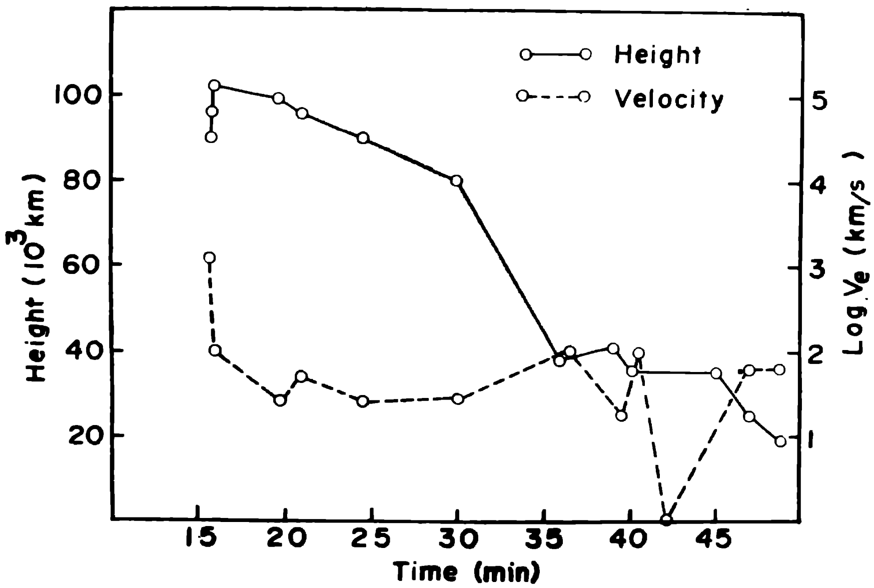

Figure 3. Height *vs* time (solid line) and velocity of expansion *vs* time (broken line) plots of the event (time of reference is 02^h10^m UT).

5. Conclusions

The eruptive prominence thus observed showed two distinct structural changes : (i) the emergence of a huge twisted rope-like structure which dragged the material from lower layers up to coronal heights and (ii) the loop formation by the falling prominence material. The splitting of the twisted vertical column can be explained on the basis of a screw-type instability in current-carrying plasma column.

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