Bull. Astr. Soc. India (1983) 11, 313–317

On the arch prominence of 1980 November 22

P. Pant and K. R. Bondal
Uttar Pradesh State Observatory, Manora Peak, Naini Tal 263 129

Received 1983 September 27; accepted 1983 October 30

Abstract. Photographic H-alpha observations of an arch prominence, its eruption and subsequent interaction with a neighbouring prominence, taken 1980 November 22 are described. The observations were obtained with a 0.7 Å passband Halle filter. Transverse velocities of some portions of this arch have been measured. An explanation is given for the violent eruption of the arch and its subsequent bending towards the neighbouring prominence and for getting joined up with it.

Key words : arch prominence—the sun

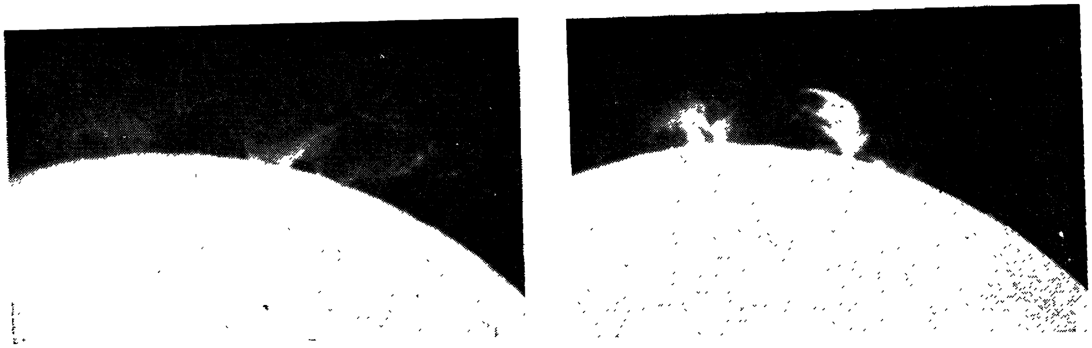
1. Introduction

On 1980 November 22 around 0230 UT, the solar limb showed an arch prominence located near the Hale plage region 17288 (Solar Geophysical Data 1980). Neighbouring it was another prominence smaller in size and with a curved sheet-like appearance. The observations of these prominences were taken through a 15 cm f/15 refractor fed with sunlight from a 25 cm coelostat, using a 0.7 Å passband H-alpha Halle filter.

In the present study we give the detailed morphological description and the interpretation for the eruption of the arch prominence at the top of the closed magnetic flux tube.

2. Observations

In the observations the exposure time used was 1/250s with the filter centred on the H-alpha line. The observations comprised of time-lapse photographs recorded on Kodak SO-115 film using a 35 mm Robot recorder camera having an automatic arrangement to register the series of events at intervals of approximately one minute. We see in figure 1a, the arch prominence on the right side tilted to one side on the solar limb at 0247 UT. On this side of the limb one of the legs of the arch, a thin spray, can also be seen emanating (S in figure 2). Sometime later a general decrease in the brightness of both prominences was noticed. The spray is no longer visible now



(a) (b)

Figures 1. H-alpha filtergrams of the arch prominence of 1980 November 22.

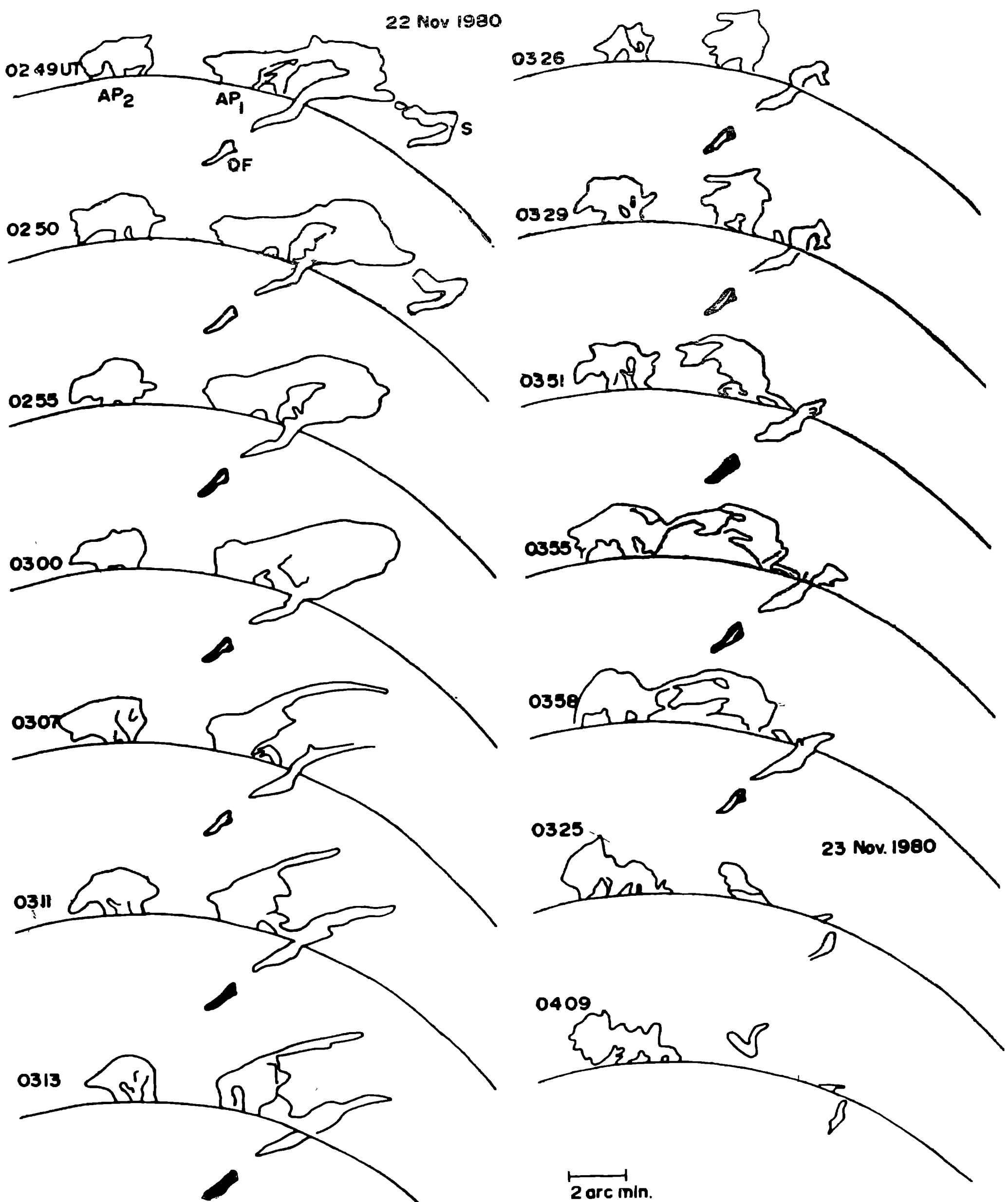


Figure 2. Line drawings of the arch prominence of 1980 November 22/23.

(figure 2, 0255 UT). The first sign of breaking up of the arch at its top appeared around 0300 UT. A noticeable feature is that the arch is non-uniform in width along its length. One leg is almost sheet-like in appearance at its junction with the solar limb. Rest of the arch is thinner and filametary in appearance. The other leg continues to extend to the solar disc as a filament (figure 2). The arch then completely got divided into two. Later, one portion, the larger one and nearer to the neighbouring prominence, shows a bending tendency towards it (figure 2, 0326 UT). The structure, as can be seen, has acquired spike-like features. It is these features which seem to connect the two prominences. The prominences at this stage have become brighter than before. Some knot-like condensations have also formed at points. The other prominence has now a divided structure, one linked up with the arch prominence part (figure 1b, 0355 UT). Careful inspection shows that the two have now formed a link and that there is a flow of matter from one prominence to the other. The arch prominence finally becomes very faint and has almost disappeared. Photographs of the same were taken on the following day also, *i.e.*, on 1980 November 23. The system looked almost stationary and devoid of any further activity. The arch prominence had almost disappeared, perhaps having lost its mass to the other prominence.

3. Transverse velocities

By making line drawings of the prominences after suitably enlarging the negatives (figure 2) it has been possible to measure the transverse velocities of some portions of the prominence. To do this, twenty-six frames were divided into groups of about six or seven each. The filtergram taken at 0250 UT was compared with that taken at 0300 UT to measure the displacement of the highest portions of the prominence AP_1 (figure 2). Having known the time interval between the two frames, the velocity was estimated. It is seen that there is a systematic increase with time in the values of the velocity thus measured. The values range from 20 to 80 km s^{-1}.

4. Possible mechanism for the disruption

The entire phenomenon, thus observed, can perphaps be explained on the basis of (i) disruption of a simple bipolar configuration, (ii) appearance of new active centres leading to, (iii) subsequent interaction of the disrupted elements. The disruption can be explained on the basis of the mechanism suggested by Sturrock (1974). We may suppose that the arch prominence is along a flux tube with its footpoints anchored to the limb. The flux tube initially has a minimum energy, *i.e.*, it is a potential field configuration with zero twist. We may now suppose that the tube undergoes a twist at its footpoints as is evident by the appearance of the helical structure of the field lines visible in figure 1a (0247 UT).

It has been shown by Sturrock (1974) that the energy content of the sheared force-free field varies with the rotation or shear angle. When the angle is zero, the field is essentially a potential field. As this angle increases, due to the rotation of the footpoints the energy also increases. Due to the rotation of the footpoints there will be a twisting of the entire flux tube. Most of the twisting will occur in the weak field region, that is, in the region at the top of the field lines.

If this twisting continues for a sufficiently long time, there will be more energy in this force-free field than in the corresponding open field. This would lead the whole configuration to an eruptively unstable state, and consequently to an open field configuration, as is evident in the later figures. The neighbouring prominence, AP_2 in figure 2, also undergoes a similar disruption, either due to the rotation of the footpoints or due to the appearance of a new active centre or of a bipolar region, resulting in the interaction of the fields.

An alternative explanation for the disruption can be given, on the lines suggested by Colgate (1978), by assuming a single twisted flux tube. Our pictures show the helical structure of the field. When a flux tube of average flux component B_z is twisted by turbulent motions (vorticity), then a new component B_θ is generated since the induction of a curret component J_z creates the B_θ component. The B_θ field dissipates, presumably because of current instabilities, and the helix partly unwinds. When the B_θ field approaches a threshold value, some of the B_z flux expands into the corona, resulting in an expulsion of the plasma previously confined by the field.

The disrupted parts of the two prominences having oppositely directed fields come closer together and reconnect (figure 2, 0355 UT). A noticeable feature of the arch prominence is that after disruption, the tilt is totally turned in the opposite direction.

The configuration has a complicated magnetic field geometry and when bent, represents an unstable system. As can be seen from the filtergrams, the arch has a helical field structure surrounding the columns of the arch (figure 1a, 0247 UT). Under this condition, the density of the lines of force surrounding the column becomes higher on the concave side than on its convex side. Consequently, the azimuthal field exerts a stronger magnetic pressure on the concave side, thereby tending to increase the curvature. On the other hand, we notice that the column has become vertical (figure 2, 0326 UT). This is attributed to the presence of the internal axial magnetic field producing a magnetic tension which acts as a restoring force and so competing with the destabilization produced by the azimuthal field. The net result would be to straighten the column, which is seen in our filtergrams.

Since the columns of the two arches turn towards each other, it is evident that the active centres have oppositely directed magnetic felds. We notice also that the columns brighten further after breaking up and during the process of attraction. The brightening of the column may be attributed to compression of the plasma brought about by the attraction of oppositely directed fields. At this moment, the appearance of a new active centre above the footpoint of which a bright column developed was noticed. In figure 1b (0355 UT) this column has brightened further and moved towards the main column, indicating the motion of the footpoint. The new column, which may have an oppositely directed field, naturally compresses the matter between it and the main column, which we see as the brightening of the feature (figure 1b). The original polarity of the main column is maintained, however. The attraction of the columns of the two prominences continues and the connection is clearly visible at 0355 UT and also in some subsequent frames. The flow of matter from one to the other is not ruled out. The various stages of the breaking up of the two prominences and subsequent reconnection are shown in figure 2.

The entire phenomenon lasted about a day and the region was photographed on the following day also. We found that the main prominence had somewhat disappeared but the other one had assumed a sheet-like appearance with a somewhat threaded structure in between.

5. Conclusions

Our observations describe H-alpha features of an arch prominence, its eruption and subsequent interaction with a neighbouring prominence. We have tried to explain the entire phenomenon on the lines suggested by Sturrock (1974) and by Colgate (1978). To support any one of the above theories, high resolution observations, both optical and magnetographic are required. Radio observations would also throw some light on the emergence of new active regions and the role played by these in the disruption and subsequent interaction of two arch prominences.

Acknowledgements

The authors thank Dr M. C. Pande for going through the manuscript critically and Dr G. M. Ballabh for his help in making some of the drawings and for discussions.

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