

Surge prominence of 1981 November 19

V. K. Verma and M. C. Pande *Uttar Pradesh State Observatory, Naini Tal 263 129*

Received 1982 April 18; accepted 1982 July 10

Abstract. Time-lapse photographic observations with 0.7 Å passband H-alpha filter and the morphological behaviour of the surge prominence recorded on 1981 November 19 have been described. The surge was recorded both in the ascending and descending phases. From these observations, the height, mass, velocity, magnetic field and mechanical energy involved in ejecting the mass material of the surge prominence were estimated.

Key words : surge prominence—mass ejection—magnetic field

1. Introduction

While monitoring the sun through a 15cm-f/15 refractor and a 0.7 Å pass band H-alpha filter on 1981 November 19 a somewhat developed surge prominence was noticed on the western limb around 0231 UT. The changes in this surge prominence were recorded photographically. We describe here the analysis of these observations and the morphological changes observed in the prominence.

2. Observations

The observations comprised of time-lapse photographs recorded on Kodak SO 115 film using Yashica FR 1 camera. The exposure time used was 1/60 s with the filters tuned to the line centre. The pictures were taken at intervals of 5 min. Since the seeing during observations was very good, all the filtergrams were used for measurements. For making line drawings, the negatives were enlarged 20 times through a spectrum projector. Outlines of the surge were traced for the study and estimation of height, mass, velocity, magnetic field and mechanical energy involved in ejecting the material of this surge prominence.

Examination of the Solar Geophysical Data (1981, 1982) also revealed the following :

(i) Associated with this surge prominence, solar radio emission was also recorded as selected fixed frequency events of simple impulsive burst type at Learmonth and Palehua (USA) from 0226 to 0231 UT. Also, spectral observations as metre band events of impulsive burst type were recorded between 0230 and 0256 UT at Learmonth and at CULG (Australia).

(ii) Sudden ionospheric disturbance was also recorded at number of stations at high frequency and low frequency transmissions during 0226 to 0548 UT.

It is very likely that these events were caused by the observed surge prominence.

3. Morphological description

Visual inspection of the filtergrams (figure 1) showed the presence of helical structure in frame I (0231 UT), indicating instability of the plasma column. From an examination of frames I (0231 UT), II (0235 UT) and III (0240 UT) it is clear that the lower portion of the plasma column is inclined towards the active centres 2 and 3, indicating attraction by these active centres. From frame IV (0245 UT) and onwards, inclination of the surge prominence to the radial direction decreases. At the frame V and onwards, this inclination becomes almost zero suggesting that the attraction by the active centre 3 becomes progressively weaker.

Examination of the frames after frame III shows that the mass ejected from the active centre 1 returns to the neighbouring active centre 2. However, transfer of mass during surge prominences has been already noticed by earlier investigators (Macris 1971).

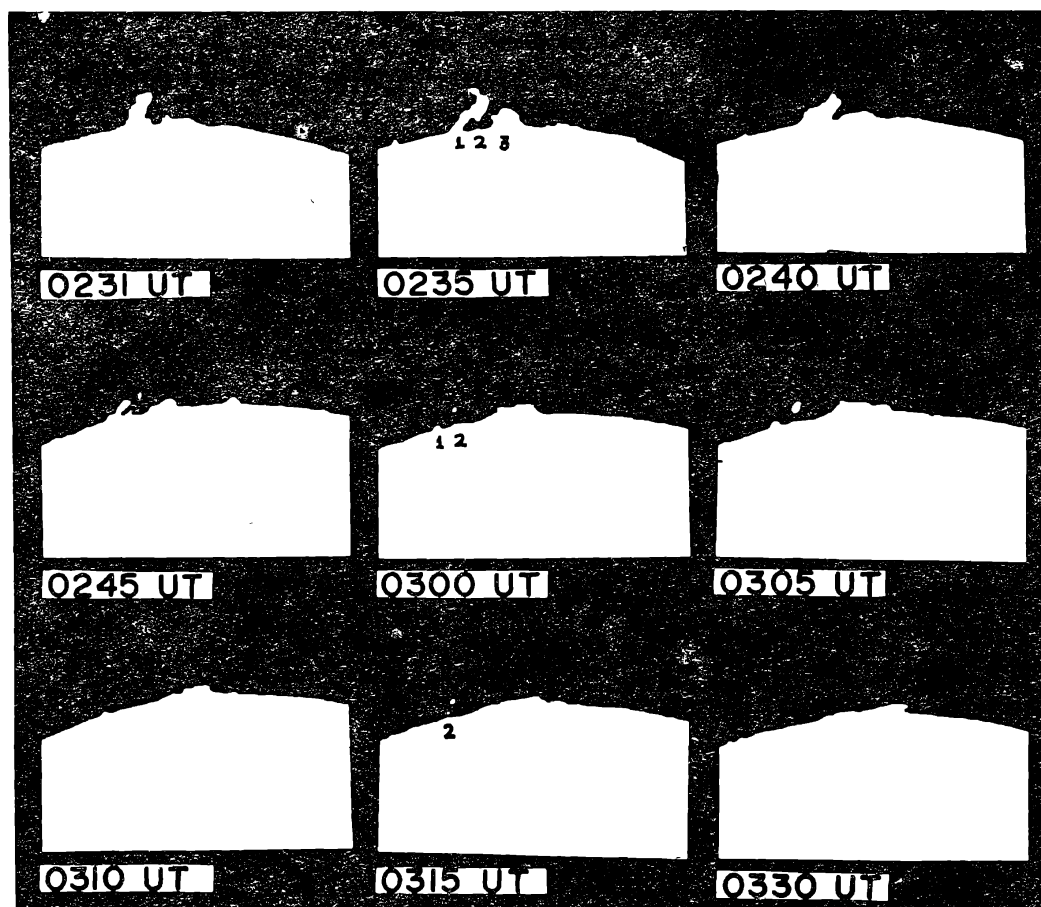


Figure 1. Some of the selected filtergrams of the surge prominence of 1981 November 19.

4. Analysis of observations

The filtergrams were analysed to obtain the following parameters as functions of time :

- (i) distance traversed by the surge material in the sky (figure 2);
- (ii) change in the inclination of the surge column from the radial direction (figure 3).

Then (i) and (ii) yielded the height attained by the surge as function of time (figure 4) and this in turn allowed us to obtain the velocity of the surge as a function of time (figure 5). In the ascending phase, the maximum height attained by the surge material was found to be nearly 15×10^4 km. For the ascending phase the maximum velocity was found to be 101 km s^{-1} and for the descending phase the maximum velocity was found to be 195 km s^{-1} . As noted earlier by Roy (1973b) and Platov (1973) the return velocity during the descending phase is found to be less than the free fall velocity.

The mechanical energy *i.e.* the sum of the kinetic energy and the potential energy was estimated for each frame and a graph was plotted (figure 6). For estimating the mass, the plasma column was idealized as a uniform cylindrical column. In estimating mass, mechanical energy and magnetic field, we assumed that the plasma density remains same throughout the surge. To estimate the magnetic field required for ejecting the surge prominence material to maximum height, we assumed that the total magnetic energy of the plasma column should be equal to its potential energy, which after some simple analysis leads to

$$\frac{B^2}{8\pi} = n_e m_H g_{\odot} h, \quad \dots(1)$$

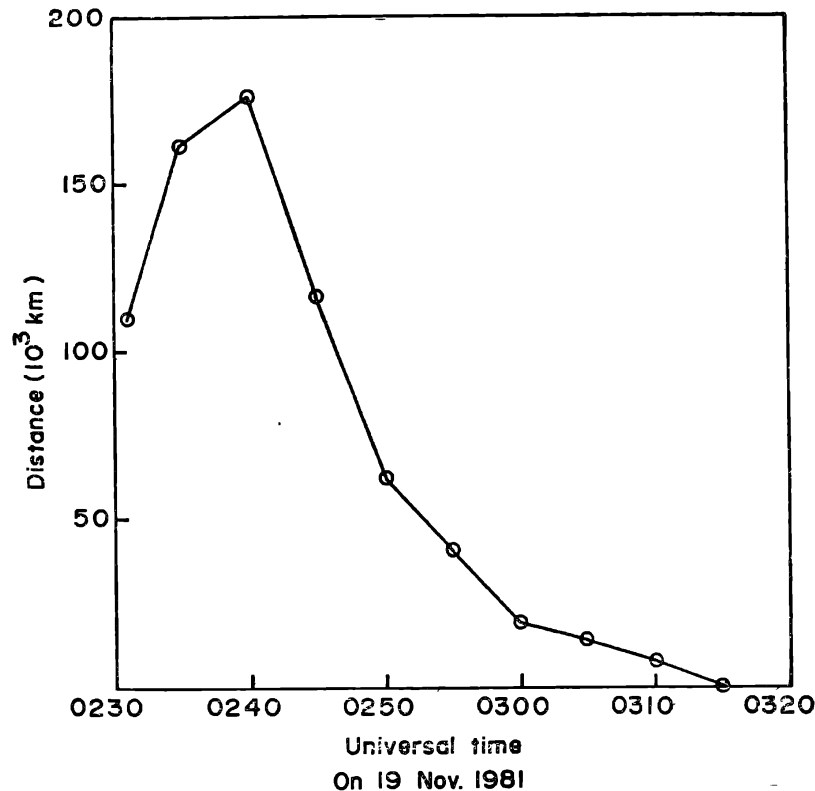


Figure 2. Plot of the distance traversed by the surge material in the sky versus time.

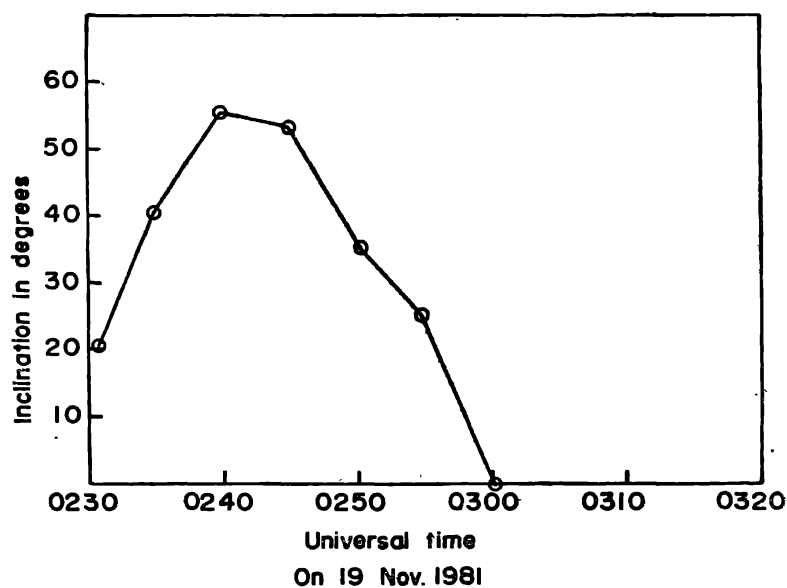


Figure 3. Inclination in degrees of the surge column with respect to radial direction as a function of time.

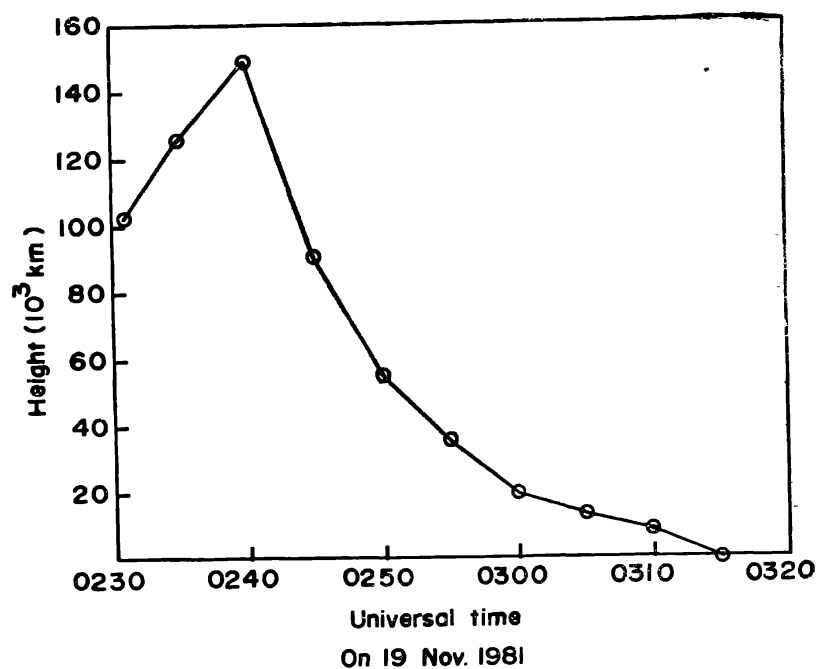


Figure 4. Height of the surge prominence above limb plotted against time.

here, m_H is the proton mass, n_e the electron density, g_\odot the acceleration due to gravity on the sun's surface, and h the maximum height attained by the surge material. In equation (1) n_e , m_H and g_\odot are almost constant in comparison to variation in h , consequently,

$$B \propto \sqrt{h}$$

which implies that the higher the magnetic field of the surge prominence, the larger will be the height attained by the surge material.

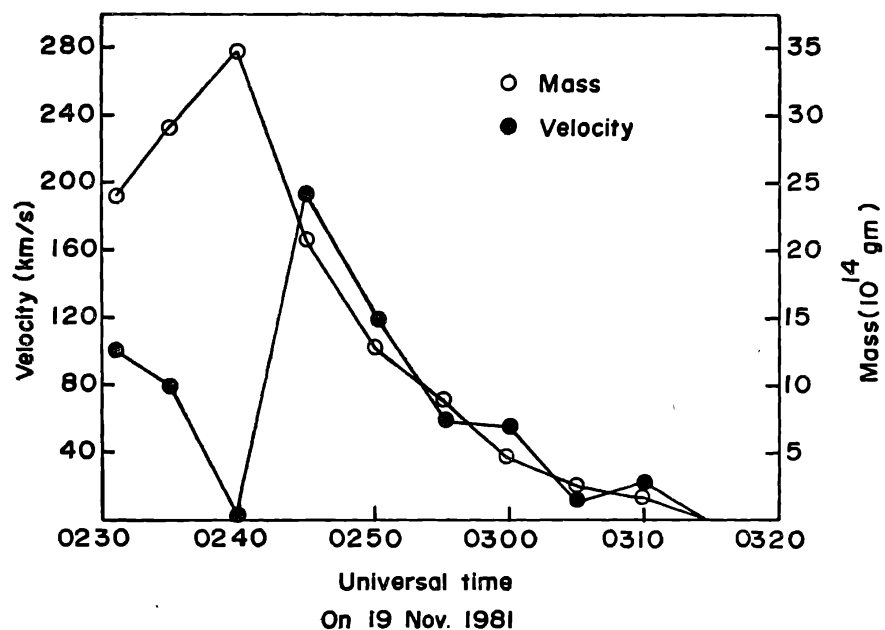


Figure 5. Velocity and mass of the surge material plotted against time (UT).

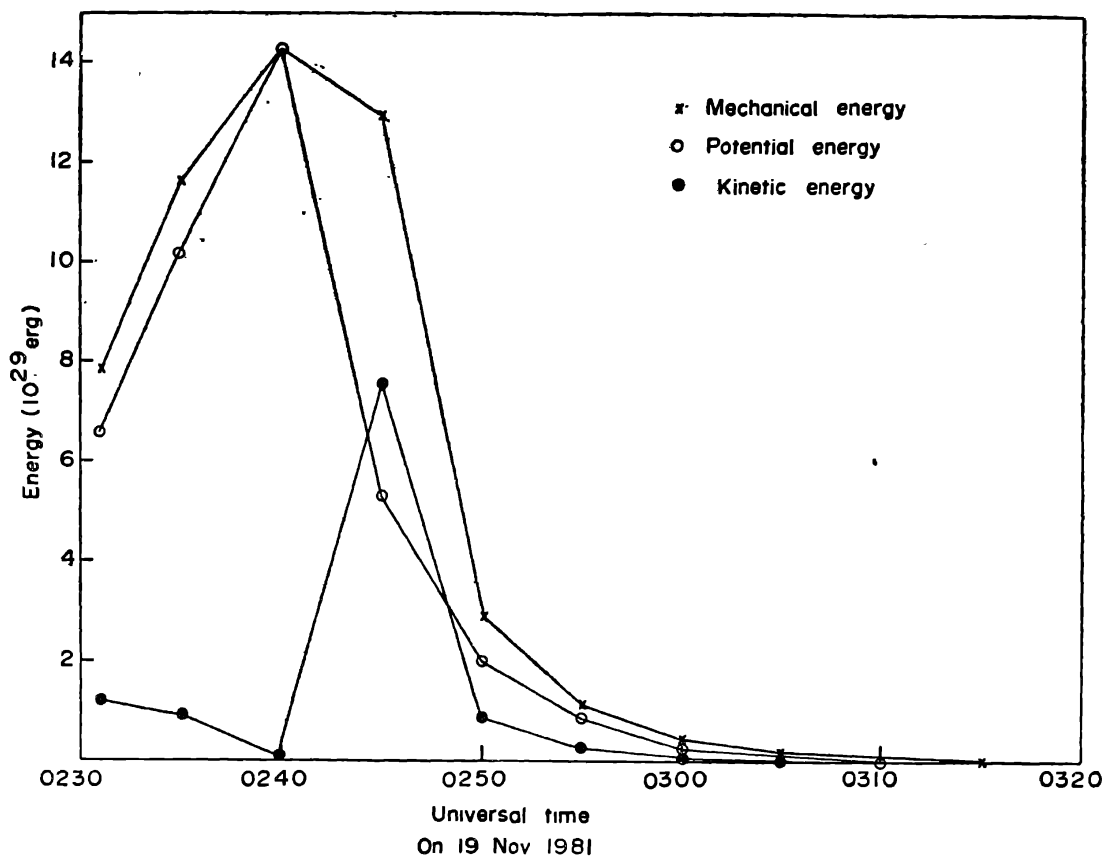


Figure 6. Plot of kinetic, mechanical and potential energies of the surge material versus time.

For $n_e = 10^{11}\text{cm}^{-3}$ and $n_e = 10^{12}\text{cm}^{-3}$ (Tandberg-Hanssen 1977) the magnetic field turns out to be $B = 41$ gauss and 131 gauss respectively in close agreement with

the magnetic fields inferred in surge prominences by other observers. Zirin & Severny (1961) and Ioshpa (1962, 1963) have found very strong magnetic fields of about 100 to 200 gauss in surge prominences. According to Tandberg-Hanssen & Malville (1974) the above fields represent the upper limit for magnetic field which usually exceeds 30 gauss.

In the estimation of the magnetic field in the preceding paragraph no concrete mechanism for the ejection of the surge material has been used. To check the above estimate, we have used the Lorentz force $\mathbf{J} \times \mathbf{B}$ as the driving mechanism (Tandberg-Hanssen & Malville 1974). In cylindrical coordinate system for helix perpendicular to the line of sight, the observed acceleration a_{\parallel} at the edge of helix has been obtained.

$$a_{\parallel} = - \frac{B^2 \sin \phi \cos^2 \phi}{4\pi \rho h} \quad \dots(2)$$

where ϕ is the angle between lines of force and the plane perpendicular to the axis of helix (Tandberg-Hanssen & Malville 1974). Here $\cot \phi = 2\pi r/\lambda$, where λ is the distance between successive turns of lines of force measured parallel to the axis of helix, ρ is the plasma density and h the height of the surge above the limb. The measurement of λ , r and h were done on frame I, and with the help of equation (2), we obtain $B = 32$ gauss and 102 gauss for $n_e = 10^{11}\text{cm}^{-3}$ and $n_e = 10^{12}\text{cm}^{-3}$ (Tandberg-Hanssen 1977) respectively. Here a_{\parallel} is taken as the average acceleration along the radial direction.

The magnetic field estimated with the help of equations (1) and (2) and values obtained are comparable, which to some extent approves our assumption.

References

- Ioshpa, B. A. (1962) *Geomagn. Aeronom.* **2**, 149.
 Ioshpa, B. A. (1963) *Geomagn. Aeronom.* **3**, 903.
 Macris, C. J. (1971) *Physics of the Solar Corona* (ed. : C. J. Macris) D. Reidel, p. 168.
 Platov, Yu. VI (1973) *Solar Phys.* **28**, 477.
 Roy, J. R. (1973) *Solar Phys.* **32**, 139.
 Solar Geophysical Data (1981) No. 448, Part I, p. 34.
 Solar Geophysical Data (1982) No. 449, Part I, pp. 130 & 152.
 Tandberg-Hanssen, E. and Malville, J. M. (1974) *Solar Phys.* **39**, 107.
 Tandberg-Hanssen, E. (1977) in *Illustrated Glossary for Solar and Solar Terrestrial Physics* (eds : A. Bruzek & C. J. Durrant) D. Reidel, p. 106.
 Zirin, H. & Severny, A. B. (1961) *Observatory* **81**, 155.