

Twisted surge of 1981 December 25

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Abstract. Photographic observations and the morphological behaviour of the surge prominence of importance class 1 recorded with the 0.7 \AA passband H-alpha filter on 1981 December 25 have been described. The surge was recorded both in the ascending and descending phases. From these observations we estimate height, mass, velocity, mechanical energy and magnetic field of the ejected surge material.

Key words : surge prominence—mass ejection—magnetic field

1. Introduction

On 1981 December 25 while monitoring the sun through a 15 cm f/15 refractor and a 0.7 \AA passband H-alpha filter, we noticed a surge prominence around 02 47 UT on the south-west portion of the solar limb, near a broken loop prominence (figure 1). The temporal changes in the surge prominence were photographed. In the present communication we present the analysis of observations and the morphological changes associated with the surge prominence.

2. Observations

The observations comprised of photographs recorded on Kodak SO 115 film using Yashica FRI camera. The exposure time used was $1/60 \text{ s}$ with the filter tuned for H-alpha line-centre. Line drawings (figure 1) were made after enlarging the images nearly 20 times through a spectrum projector. From these line drawings we estimated the height, mass, velocity, mechanical energy and the magnetic field strength involved in ejecting the surge material. Also, associated with this surge sudden phase anomalies were recorded between 02 50 UT and 03 09 UT (Solar Geophysical Data 1982).

3. Morphological description

Visual inspection of the films shows that the surge was ejected from the boundary of an active region. The material was initially ejected in a conical shape (figure 1) (02 47 UT) but after some time it assumed a twisted shape (02 50 UT) showing that

the material travelled along a spiral trajectory. This kind of behaviour in a surge prominence has been observed earlier also (Dizer 1968). After some time (02 55 UT), during the descending phase, the helical structure disappeared, and the surge material returned to the solar surface in the form of a straight column.

4. Analysis of observations

To estimate the magnetic field strength involved in ejecting the surge material the following assumptions were made : (i) The energy loss due to radiation in H-alpha and the energy loss due to expansion of the surge material is negligible compared to the total mechanical energy. (ii) The magnetic energy of the surge material is equal to its total mechanical energy.

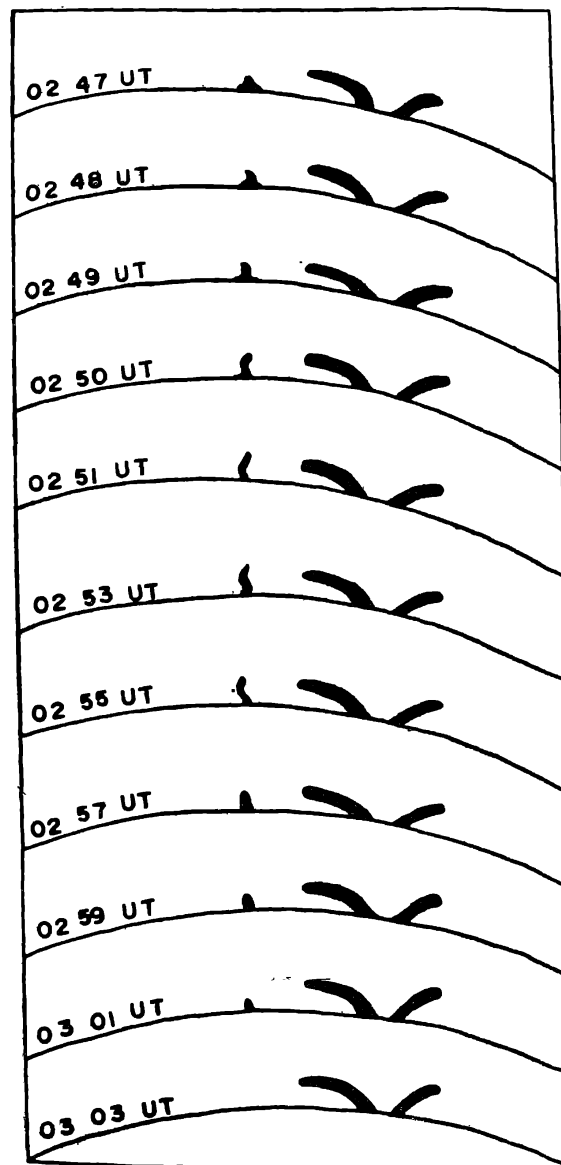


Figure 1. Line drawings of the surge prominence of 1981 December 25.

Using assumption (ii) and after simple analysis, we have

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

where B is the magnetic field, m_H the proton mass, n_e the electron density, v the velocity, h the height and g_{\odot} the acceleration due to gravity on the sun.

Also, at the maximum height (*i.e.* when $v = 0$), equation (1) gives

$$B^2 = 8\pi n_e m_H g_{\odot} h_{\max} \quad \dots(2)$$

In equation (2) n_e , m_H and g_{\odot} can be taken as constants in comparison to variation in h , consequently, $B \propto (h_{\max})^{1/2}$.

From the observed data we estimated the following parameters as functions of time: (i) height attained by the surge material during the course of its journey (figure 2); (ii) mass of the surge material (figure 2); (iii) the velocity of the surge material of radial direction (figure 3); and (iv) kinetic, mechanical and potential energy densities as functions of time (figure 4).

A magnifying eyepiece (magnification 7) with a millimetre scale having a least count of 0.1 mm has been used for measurements. In each plot the error is shown by vertical bars.

In the ascending phase maximum height attained by the surge material was found to be nearly 37×10^3 km which shows that the present surge is of importance class 1 of Westin (1969).

For the ascending phase the maximum velocity was found to be 93 km s^{-1} in radial direction. We find that return velocity is not a free fall velocity as already noticed by Roy (1973) and Platov (1973). In order to estimate the mass of the surge material

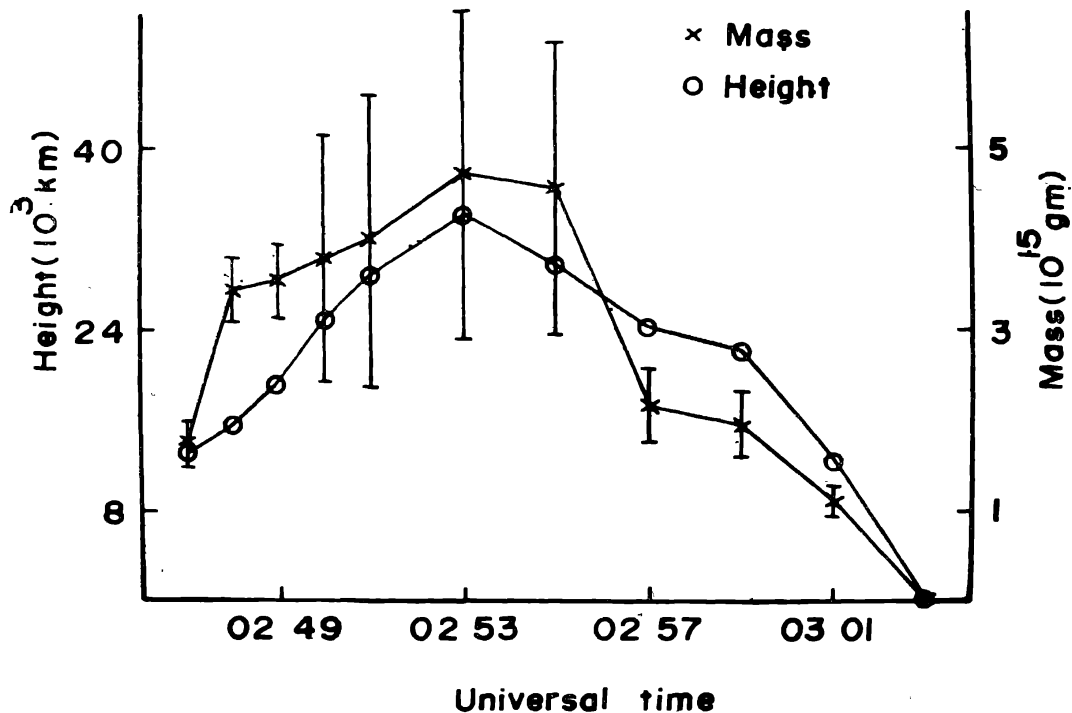


Figure 2. Height of the surge prominence above limb and mass of the surge material plotted against time.

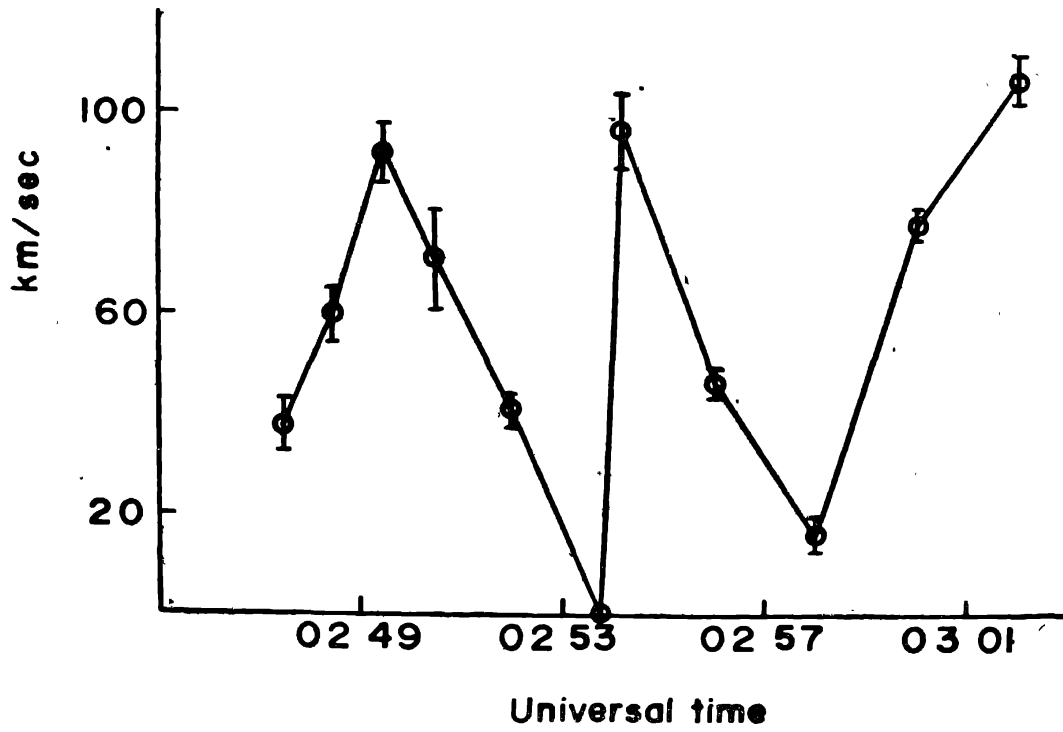


Figure 3. Velocity of the surge material plotted against time.

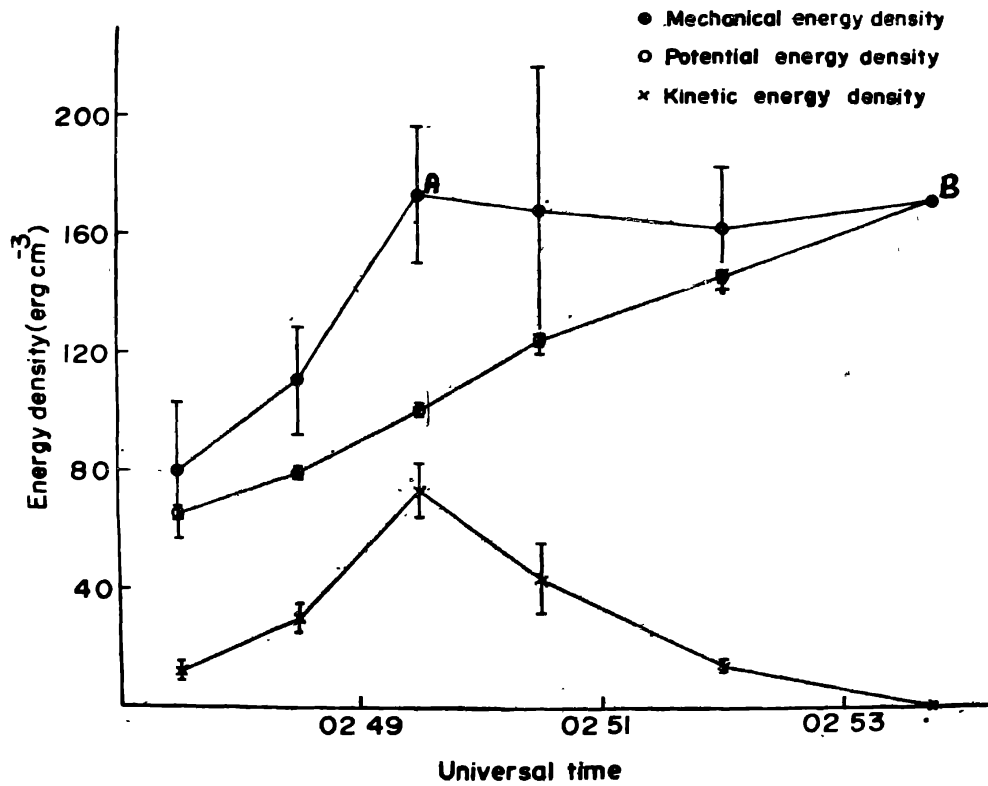


Figure 4. Plot of kinetic, mechanical and potential energy densities of the surge material versus time.

at different moments (figure 2), we assumed different structures for different frames viz. cone, uniform cylinder and helix structure. From figure 4 it is clear that the mechanical energy density after maximum velocity stays nearly constant which indicates that the magnetic field inferred from equation (1) is also constant between the points A and B.

We also estimated the magnetic field strength associated with the surge material and found it to be 65 G from equations (1) and (2) taking $n_e = 10^{12} \text{ cm}^{-3}$ (Tandberg-Hanssen 1977). Zirin & Severny (1961) and Ioshpa (1962, 1963) have found magnetic field strengths of the order of 100 G to 200 G in different surge prominences. According to Tandberg-Hanssen & Malville (1974), the above value of magnetic field represents the upper limit which usually exceeds 30 G. In table 1 the maximum values of the estimated height, velocity, mass, kinetic energy, mechanical energy, potential energy and magnetic field strength for the surge are shown.

Table 1. Estimated parameters of the surge of 1981 December 25

Height	$37 \times 10^3 \text{ km}$
Resultant velocity (radial)	93 km s^{-1}
Mass	$4.69 \times 10^{15} \text{ gm}^*$
Kinetic energy	$1.55 \times 10^{29} \text{ erg}^*$
Potential energy	$3.45 \times 10^{29} \text{ erg}^*$
Mechanical energy	$3.68 \times 10^{29} \text{ erg}^*$
Magnetic field	65 G^*

*With $n_e = 10^{12} \text{ cm}^{-3}$

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