PARTIAL ANALYSIS OF THE
FLARE-PROMINENCE OF 30 APRIL 1974

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Abstract. A portion of an east limb flare-prominence observed in Hα by NOAA/Boulder and NASA/MSFC patrol facilities on 30 April 1974 is analyzed. Following a rapid (~ 2 min) achievement of a maximum mass ejection velocity of about 375 km s⁻¹, the ascending prominence reached a height of, at least, 2 x 10⁵ km. We use a one-dimensional, time-dependent hydrodynamic theory (Nakagawa et al., 1975) to compute the total mass (~ 2 x 10¹¹ g) and energy (~ 4 x 10⁴⁸ erg) ejected during this part of this event. Theoretical aspects of the coronal response are discussed. We conclude that a moderate temperature and density pulse (factors of ten and two, respectively), for a duration of only 3 min, is sufficient for an acceptable simulation of the Hα observations and the likely coronal response to the ascending prominence and flare-related ejections. No attempt was made to simulate the additionally-important spray and surge features which probably contributed a higher level of mass and energy efflux.

1. Introduction

Simulation of a flare-prominence presents a formidable challenge to the theoretician. In addition to the obvious complexity of three-dimensional motion, considerations such as the multifluid nature of the plasma, magnetic topology and importance of Lorentz forces, dissipation forces, and radiation effects arise to plague the model-maker. In an effort to describe some of the available observations of particular events, the theoretician seeks to simulate essential features by building his model in a step-by-step fashion. The history of initiating fluid dynamical studies, however complex, with non-magnetic, one-fluid, one-dimensional flow is well known. Thus, it comes as no surprise to note that simulation of complex solar phenomena has proceeded in a similar way. The present study is consistent with this philosophy.

Recent Hα observations of a flare-prominence on 30 April 1974 presented an opportunity for examination of a fluid model recently described by Nakagawa et al. (1975). Starting with a hydrostatic, isothermal solar atmosphere (i.e., a steady-state solution of a hydrodynamic model), these workers pulsed this quiescent state with various kinds of inputs of varying durations. They found that it was possible to simulate some features of various solar phenomena (sprays, surges, and eruptive prominences) by the choice of velocity, temperature and/or density pulses. Hence, without claiming any

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additional knowledge of underlying physical causes of these phenomena, they were able to set some general limits on the likely magnitudes of dynamic and thermodynamic parameters which are associated with the generation of solar disturbances.

We will apply the approach taken by Nakagawa et al. (1975) to the solar patrol observations of the flare-prominence of 30 April 1974. We will show that the major observations of the mass motion velocity history can be simulated satisfactorily without reference to a spray and fountain which also were observed. Having done so, we will inquire further as to the coronal response and some of its disturbed average properties in the corona. Finally, we will use the theoretical computations to estimate the mass and energy efflux to the interplanetary medium as a result of our interpretation of a part of the entire event.

2. Hα Optical Observations

The solar event that began at 1755 UT on 30 April 1974 was classified as only a bright subflare in the optical reports, but the accompanying spray prominence, surge, ‘fountain’ (cf. Tandberg-Hanssen et al. (1975) for examples of this type of ascending prominence), radio burst and X-ray intensity indicated a more important event. The Preliminary Report and Forecast of Solar-Geophysical Data from NOAA reported type III radio bursts of intensity 3 and strong continuum radiation in the 240–480 MHz range. No other optical reports, or type II or type IV bursts, have been reported to our knowledge. The X-ray burst was measured as M5 ($5 \times 10^{-2}$ erg cm$^{-2}$ s$^{-1}$) by the SOLRAD satellite. This disparity between nonoptical and optical classifications for a flare is not unusual for an event at the solar limb (S10 E85). An important part of the flare may have occurred beyond the limb, or it may have been obscured by some elevated material near the active region as suggested by the geometry of the flare and prominence event in Figure 1. Nevertheless, we believe that the major observed radial motion of the ascending prominence provides a sufficient basis for the analysis described in Section 3.

We emphasize, parenthetically, that this was an unusually complex event in spite of its apparent lack of type II and IV radio emission. The motion which we choose to study (Figure 1) was only a part of the event. As noted above, a large spray prominence and surge (Hansen, 1975) were also observed. The spray apparently moved at speeds greater than those for the ascending prominence. In fact, a small portion of the spray was separately ejected at a velocity of $\sim 1300$ km s$^{-1}$ (Wagner, 1975). The overall description of the event may be categorized as that of a ‘fountain’. The ‘fountain’ is defined by Tandberg-Hanssen et al. (1975) as a “sub-class of ascending prominence characterized by closed-system transference of chromospheric material along an arch or loops ... (while) ... the entire prominence envelope steadily rises upward and expands through the corona”. No detailed information (such as a plot of height vs time) is as yet available for the spray or fountain. Hence we caution that the analysis discussed below pertains only to a portion of the major features and that a complete study (especially the total mass and energetics) must await further study. In summary,