FLARE PARAMETERS FOR THE 7 SEPTEMBER, 1973
TWO-RIBBON FLARE

J. G. DOYLE
Armagh Observatory, Armagh BT61 9DG, N. Ireland

and

J. C. RAYMOND
Harvard-Smithsonian Center for Astrophysics, 60 Garden Street, Cambridge, MA 02138, U.S.A.

(Received 7 April; in revised form 9 September, 1983)

Abstract. A study is made of the relative importance of the various energy loss mechanisms for the long-decay event of 7 September, 1973, using spectral scans in the 400 Å–1335 Å range. This spectral range contains many of the important electron density and temperature diagnostic line ratios for the solar transition zone. We refine earlier analyses of the flare energy budget using more detailed emission measure curves and density diagnostics. We examine the constant pressure assumptions used in both coronal loop models and in the interpretation of observations in terms of flare energetics. We find that much of the upper transition region emission originates in cooling loops. Radiative losses are found to dominate.

1. Introduction

During a solar flare, material in the corona is heated rapidly to high temperatures. After the plasma reaches a peak temperature of the order of $10^7$ K, it loses energy through radiation, conduction and mass flow, and eventually cools, returning to its original non-flaring state. The study of the thermal history of this plasma provides much insight into the physical processes at work in the flare. Such studies have been undertaken by a number of authors, with particular emphasis on the decay phase, e.g. Culhane et al. (1970), Craig et al. (1978), Underwood et al. (1968), Dere and Cook (1979, 1983), and Widing and Spicer (1980).

Broadly speaking, there are two types of flares (see Priest, 1981), the compact flare and the two-ribbon flare. The compact flare usually consists of small loop type structures lasting from a few minutes to a few tens of minutes, whereas the two-ribbon flare is a much larger event, so-called because of two ribbons of Hα emission which move apart following the eruption of the filament separating them.

Here we analyze EUV spectral scans for one of these two-ribbon flares, taken with the Harvard College Observatory instrument on board Skylab on 7 September, 1973. This flare was one of the largest observed by Skylab, X-ray class X1, and emitted strongly in the radio, visible, EUV and soft X-rays. Withbroe (1978) studied this event using two-dimensional spectro-heliograms taken in Lα λ1216, C II λ1335, C III λ977, O vi λ1032, and Mg X λ625 and Solrad-9 soft X-ray data. Here we use the spectral lines in the wavelength range 400 Å–1335 Å, which include many of the important electron density diagnostics for the transition zone, to examine the assumption of constant...
pressure which is made in most models of flare loops and in assessments of flare energetics.

In Section 2 we discuss the present observational data and briefly summarize previously published observations. In Section 3 we evaluate the electron density diagnostics and data analysis techniques. Finally in Sections 4 and 5 we determine the energy balance and compare our results with those previously published.

2. Observations

A full description of the EUV observations can be found in Withbroe (1978) and details of the Harvard instrument and its calibration can be found in Reeves et al. (1977a, b). Briefly, spectral scans covering the wavelength range 1335 Å–400 Å were taken at 12:55, 14:03, 15:52, 16:00, and 16:07 in 0.2112 Å steps. The gate time was 0.045 s and the FWHM approximately 1.6 Å. Also, one and two-dimensional spectroheliograms were taken in the above-mentioned lines between 12:22 and 16:00 UT. The spectral scans were taken over a 5 x 5 arc sec area, while the rasters covered a 5 x 5 arc min area. The spatial location of the spectral scan taken at 12:55 UT was near the top of one of the loops, while the 14:03 UT spectral scan was located in one of the loop footpoints. The remaining spectral scans were located approximately mid-way up the loop.

In Figure 1 we show a plot of the Solrad-9 soft X-ray flux (Withbroe, 1978), with the times of the EUV spectral scans and rasters marked. This event was also observed in soft X-rays by the AS&E S 054 grazing-incidence X-ray telescope on Skylab (Pallavicini and Vaiana, 1980). The X-ray event was of approximately 7 hr duration with a rise-time.

Fig. 1. Solrad-9 soft X-ray flux (1-8 Å) for the 7 September, 1973 flare from Withbroe (1978). + represents times at which the spectral scans were taken and O the spectroheliograms.