September 7 1973 Two-Ribbon Flare

J.G. Doyle[1] K.G. Widing[2]

[1]Armagh Observatory, Armagh, BT61 9DG, N. Ireland

[2]E.O. Hulburt Center for Space Research, Naval Research Laboratory, Washington D.C., 20375 U.S.A.

Abstract: *The flare images show a compact, nearly cylindrical arcade centered along the filament channel and composed of 4 prominent loops. The loop systems of Fe XII (T_e = 1.7 $10^6 K$) and Fe XIV (T_e = 2.3 $10^6 K$) are smaller than, and lie nested within, the arcades of Fe XVI (T_e = 3 10^6 K) and Ca XVII (T_e = 5 $10^6 K$). The loop arcades at different temperatures, as well as different loops within a given arcade, show different expansion rates. These vary from* 6 – 8 $km\ s^{-1}$ *for Fe XIV shortly after flare maximum to* 0.5 – 1 $km\ s^{-1}$ *late in the decay phase. For hotter ions, such as Ca XVII, the velocities are approximately constant at* 2 – 3 $km\ s^{-1}$ *during the whole of the observations.*

1 Introduction & Observational Data

Here, we discuss XUV (170 - 3400Å) data of a class 2B two-ribbon flare which started at 11:40 UT, peaked around 12:05 and ended around 19:00 UT on 7 September 1973. This flare emitted strongly in several wavelength regions, including radio, visible ($H\ \alpha$), soft X-rays, UV (1000 2000Å), EUV (400 - 1000Å) and XUV (170 - 340Å) causing a coronal transient and a shock wave to collide with the Earth's atmosphere two days later. The observations described here were taken with the NRL S082A experiment onboard SKYLAB. This was a slitless spectroheliograph, with a field-of-view of 1.75 solar diameters and a spatial resolution of 1-2 arc sec. covering the XUV wavelength range 170 - 340Å with a spectral resolution of 0.02Å. The advantage of the instrument, was that a single exposure recorded the full-disk, showing solar features in spectral lines whose temperatures range from 10^4 to $10^7 K$, giving both simultaneous high spatial, spectral and temporal resolution. Typical flare exposures times ranged from 1 to 40 seconds.

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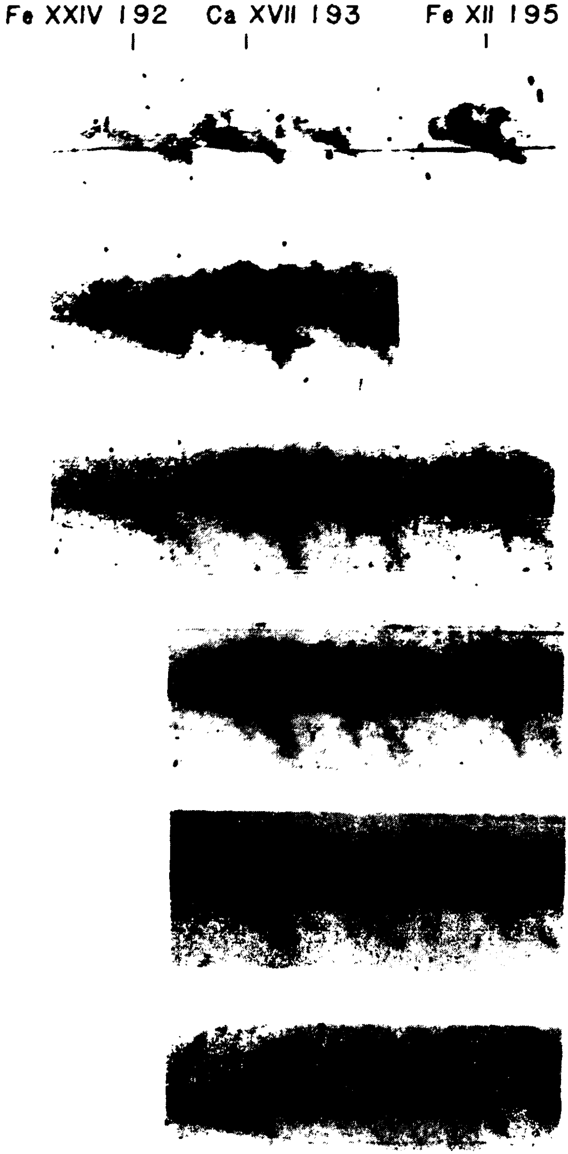
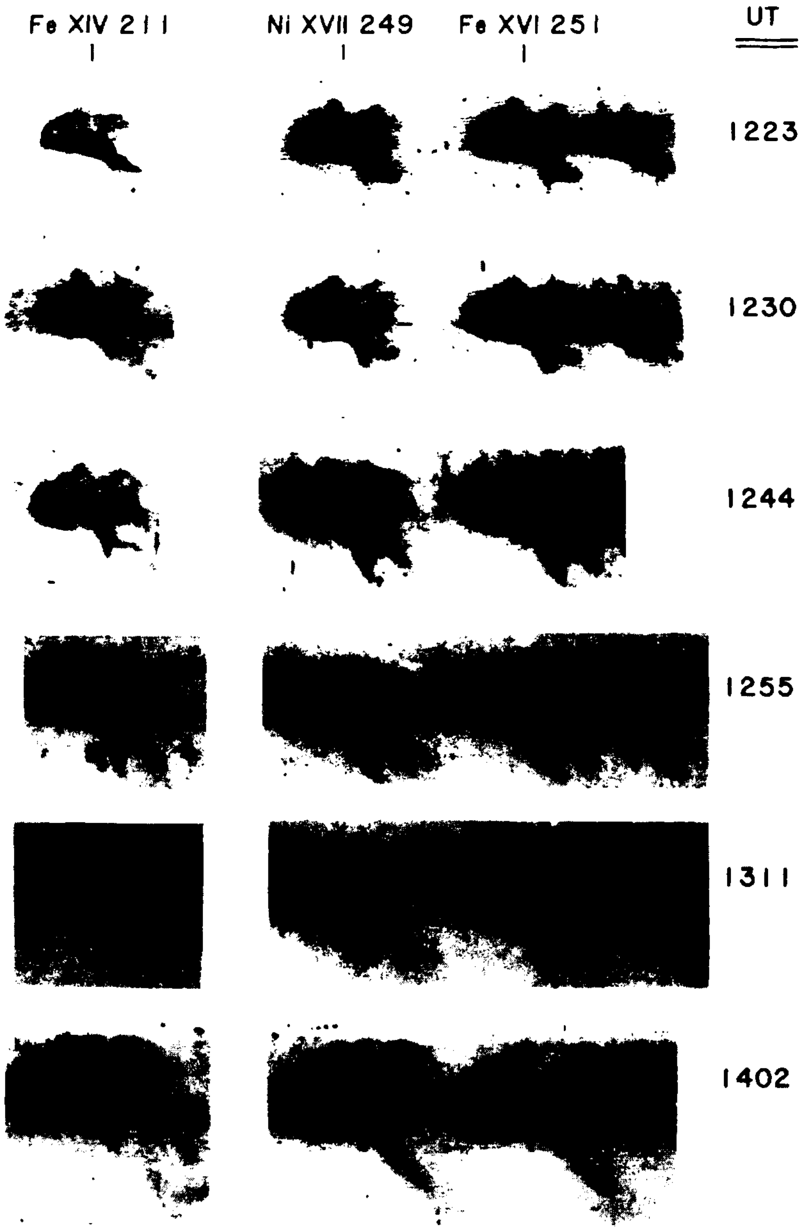

Fe XXIV 192
Ca XVII 193
Fe XII 195



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The first NRL spectroheliogram was obtained at 12:21 UT when SKYLAB emerged from the night side orbit. A time-sequence of images is given in Fig. 1. A weak Fe XXIV 192Å image is present during the first 30 minutes of observations showing that some flare plasma was at temperatures greater than $10^7 K$. However, the Ca XVII 192Å image, along with Fe XVII 254Å, represent the highest temperature ions continuously present.

2 Overall Morphology of the Loops

The flare image in each ion consists of a compact, nearly cylindrical arcade of loops spanning the magnetic neutral line. The different loops of the sets labelled A, B and C all seem to lie within the same vertical plane normal to the neutral line — only differing in altitude — the Ca XVII and Fe XVII loops being the highest at any particular time, and the Fe IX, Fe XII loops of the set being the lowest. Furthermore, the growth of the loop system in time continues upward in the same vertical plane. Thus, within the cylindrical, expanding flare arcade there seem to be a limited number of preferred vertical planes, or cross-sections, where the physical parameters of T_e and N_e are such as to produce prominent emission. Individual loops appear to be approximately circular and cylindrical. There is no noticeable variation in the loop width along their length during the period of the NRL observations until 13:11 UT, when the C-loop in Fe XIV shows a masked divergence toward the apex, resembling a separation into multiplet loops. Other loops in Fe XIV, as well as in Fe XII, Fe XVI and Ca XVII at this time do not show this effect.

3 The Loop Expansion

At the start of the observations at 12:21 UT, the Ca XVII loop ($T_e = 5\ 10^6 K$) are located at higher altitude (12,000 to 18,000 km) than the loops of Fe XIV and Fe XVI (10,000 to 15,000 km) but grow upward at a slower rate (2.1 to 3.9 km s^{-1}) than the others (5.2 to 8.6 km s^{-1}). Moreover, the upward growth in Ca XVII proceeds at a uniform rate compared with the conspicuous de-acceleration observed in Fe XIV and Fe XVI. Eventually, however the C-loop of Fe XVI, Ni XVII *catch up*, and are observed at nearly the same altitude as those of Ca XVII (after 12:42 UT).

We have also measured the separation rate of the He II ribbon and compared it with the expansion rate of the loop end-points. For the C-loop in Fe XII and Fe

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XIV, there is excellent agreement between the separation of the loop end-points and the separation of the corresponding foot-points in the He II ribbon. For the A-loop, the expansion of the loop end-points followed a curve similar to the foot-points in the ribbon, but the separation of the loop end-points were 10 – 15% smaller. This suggests that the foot-points of the A-loop in the ribbon have been precisely identified.

4 Loop Width

By visual inspection of the images it is seen that the loop width remains approximately constant along their length. For a circular loop of diameter D, having a cylindrical cross-section with minor diameter d, the aspect ratio can be defined as d/D. The aspect ratio of the Fe XIV loops is initially 0.3, but tends towards 0.1 after one hour as the loop size increases. For Ca XVII, the aspect ratios are approximately 0.17 for the C-loop and 0.3 for the A-loop, with less variation with time.

5 Intensities at Loop Apex

The loop intensities change relatively little over the first hour, in spite of the increase in the loop size by about a factor of two. In fact, the intensities of the C-loop increase during the first 10 to 20 minutes of observations when the upward growth of the loops is fastest, illustrating how strongly the energy and mass supply to the growing flare arcade are sustained in the first hour after soft X-ray flux maximum. The different behaviour of the A and C loops intensities reveal differences in the detailed evolution of individual loops within the growing arcade. The A-loop is strongly present in the first observation, and is scarcely diminished in intensity two hours later in the Ca XVII image. The intensity of the C-loop, on the other hand, rises to a maximum between 12:30 UT and 12:40 UT, and then fades. The fading of the C-loop is especially noticeable in the images of the higher ionization states, such as Ca XVII and Fe XVII. Two papers dealing with these observations are to be submitted to the *Astrophys. J.*

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