Abstract. The analysis of the high temperature plasma in Fe XXIII-XXIV in the 15 June 1973 flare is presented. The observations were obtained with the NRL XUV spectroheliograph on Skylab. The results are: (1) There was preheating of the active region in which the flare occurred. In particular, a large loop in the vicinity of the flaring region showed enhanced brightness for many hours before the flare. The loop disappeared when the flare occurred, and returned in the postflare phase, as if the energy flux which had been heating the large loop was blocked during the flare and restored after the flare was gone. The large magnetic fields did not change significantly. (2) The flare occurred in low-lying loop or loops. The spatial distribution of flare emission shows that there was a temperature gradient along the loop. (3) The high temperature plasma emitting Fe XXIII and XXIV had an initial upward motion with a velocity of about 80 km s\(^{-1}\). (4) There was large turbulent mass motion in the high temperature plasma with a random velocity of 100 to 160 km s\(^{-1}\). (5) The peak temperature of the hot plasma, determined from the Fe XXIII and XXIV intensity ratio, was 14\(\times\)10\(^6\) K. It decreased slightly and then, for a period of 4 min, remained at 12.6\(\times\)10\(^6\) K before dropping sharply to below 10\(\times\)10\(^6\) K. The density of the central core of the hot plasma, determined from absolute intensity of Fe XXIV 255 Å line, was of the order of 10\(^{11}\) cm\(^{-3}\).

The persistence of the high level of turbulence and of the high temperature plateau in the decaying phase of the flare indicates the presence of secondary energy release. From the energy balance equation the required energy source is calculated to be about 3 to 7 ergs cm\(^{-3}\) s\(^{-1}\).

1. Introduction

Solar flares have been observed extensively in many wavelength regions. In particular, observations made in H\(_\alpha\) and soft X-rays have shown that the flare emissions consist mainly of two components; a relatively cool chromospheric plasma which has a temperature of more than 10\(^4\) K, and a high energy plasma at temperature of about 10\(^7\) K, which emits X-rays. The properties and the dynamic structures of the cool plasma, which, in high time and spatial resolution H\(_\alpha\) observations, often appears as a double ribbon with a strand located on each side of the photospheric neutral line, are better known. Although a large body of observations made in soft and hard X-rays now exists, the structure and properties of the high temperature plasma are less well known. This is mainly because of the low spatial and spectral resolutions of the X-ray instruments used. For example, an accurate determination of temperature of the hot plasma has not been possible with flare images obtained by broad-band grazing incidence X-ray telescopes, owing to the difficulties of differentiating emissions through different filters (Underwood and McKenzie, 1977). In addition, previous observations were made, in most cases, in particular
wavelength regions for different flares. As a result, the precise distributions of the flare emissions originating from plasmas with a wide range of temperature, the relationship between the cool and hot plasmas and their evolutions, and the energy release processes cannot be unambiguously determined.

Recent observations of flares, at high spatial and time resolution, with X-ray and XUV instruments on Skylab, offer an opportunity to study flare emissions in more detail than was possible before. In particular, the NRL slitless objective grating spectrograph (S082A) demonstrated a unique capacity for the observation of solar flares. The S082A covers the wavelength region from 160 to 630 Å, which contains distinct line images of flare emissions characterized by temperatures from $10^5$ K to $2 \times 10^7$ K. With spectrally separated images and a spatial resolution approaching 2", the spatial structure of flare plasmas over a wide temperature range can be studied. Of particular interest is the comparison of the adjacent images of Fe xxiv 255 Å and the He ii 256 Å, which shows almost at a glance the relative locations of the high temperature plasma and the cooler chromospheric ribbons.

Among the many flares observed by the NRL slitless spectroheliograph, the 15 June, 1973 flare was probably the largest and best observed. The initial XUV results on this flare have been discussed by Widing and Cheng (1974), Cheng and Widing (1975), and Brueckner (1976). Widing and Dere (1977) recently have discussed multiple loop activations associated with this flare. The UV slit spectra of this flare obtained with the NRL slit spectrograph (S082B) have been discussed by Doschek et al. (1977), and Feldman et al. (1977). The Skylab X-ray results on this flare have been presented by Pallavicini et al. (1975), and Smith et al. (1977).

In this paper, the analysis of the evolution of the high temperature plasma in the 15 June, 1973 flare is presented. We discuss the preflare enhancement of loops in the active regions, and the determination of temperature and density as a function of time for the hot plasma. We also deduce the turbulent velocity in the high-temperature plasma from the comparison of line widths of the Fe xxiv doublet at 192 and 255 Å. These enable us to study the energy release processes in the flare.

2. The Observations

The 15 June, 1973 flare occurred in the McMath region 12379 on the solar disk at N17 W32. The Hα event was a two-ribbon flare of importance 1B, which started at 1401 UT and reached maximum at 1413 UT. A detailed description of the history of observations in X-rays, radio, and Hα has been presented by Pallavicini et al. (1975), and will not be repeated here.

XUV spectroheliograms were obtained with the S082A instrument starting from 1411 UT to 1430 UT. The first XUV flare observation was just after the cessation of the impulsive microwave bursts and near the peak of the 0.5–3 Å X-ray flux. We first describe the preflare and the postflare phases, and then the post impulsive phase.