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CHARACTERISTICS OF MICROFLARES SEEN IN HELIUM-LIKE SULPHUR SPECTRA: GOES A-CLASS FLARES DURING THE MINIMUM ACTIVITY PHASE

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Abstract

The maximum temperatures and emission measures of the helium-like sulphur lines are obtained for small events observed by *Yohkoh.* They correspond to A - C class events in the GOES scale. The maximum temperature derived from the helium-like sulphur line is nearly constant and does not dependend on the size of flare.

1. Introduction

One of the fundamental questions in the flare physics is what physical conditions determine the flare size. The flare size in this context is defined by the soft X-ray intensity, such as in the GOES monitor, and one of the channels for the soft X-ray emission lines (SXV, CaXIX, FeXXV, and FeXXVI) of BCS on board *Yohkoh.* The condition relating the instantaneous energy deposition/transport rate to the total energy of flare gives a clue for understanding the energy release mechanism of solar flares. Watanabe (1983) showed a decade ago that the maximum temperature of the FeXXV lines and the 5 - 12 keV soft X-ray continuum in flares was nearly independent from the flare size, namely, the GOES 1 - 8 Å intensity, using the data of *Hinotori.* The maximum emission measure of 20×10^6 K plasmas could be easily estimated, once the GOES intensity would be known. The absolute values of the maximum temperature and the emission messure differ with each others in different soft X-ray lines or broad-band intensities. So, this implies that solar flares have a universal differential emission measure distribution irrespective of their sizes.

Recently *Yohkoh* has learned a lot about microflares (Shimizu *et al.* 1992, Shimizu *et al.* 1994a, b), which could be responsible for the coronal heating (Parker 1988, Sturrock *et al.* 1990). Hudson (1991) pointed out that the change of slope in the occurence frequency vs total energy diagram is required so that microflares can contribute to the coronal heating. It is observationally suggsted that characteristics of microflares seen in the UV wavelengths may be different from those seen in X-rays (Porter *et al.* 1993).

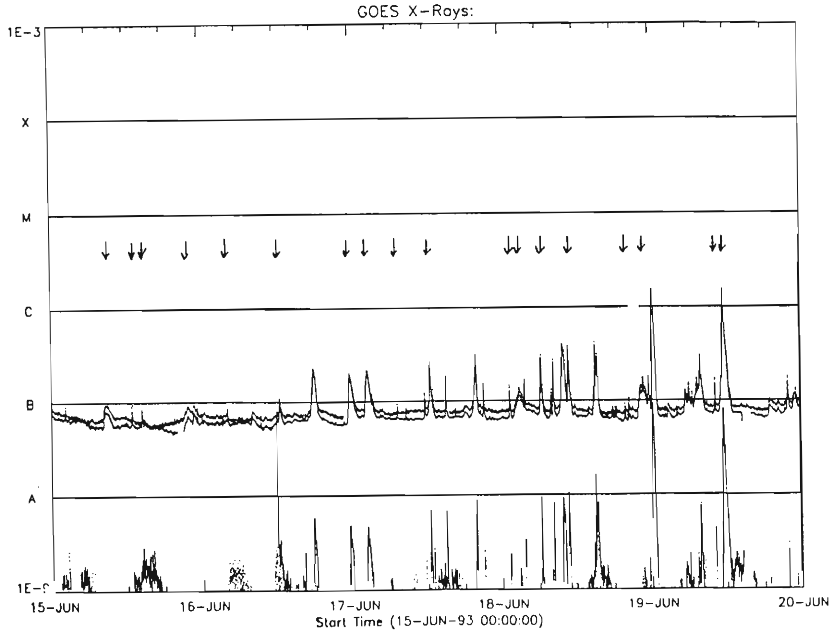

Fig. 1. GOES plot for the period of June 15 - 20, 1993

In this study, the maximum temperatures as well as the maximum emission measures, derived from the SXV lines are investigated for the events during June 15 - June 20, 1993, one of the minimum activity phase since the launch of *Yohkoh*, when the quiescent GOES level stayed in the A-class range (10^{-7} - 10^{-8} Wm^{-2}).

2. Observations

During the period of June 15 - June 20, 1993, *Yohkoh* had 18 flares in total, the both phases of the maximum temperatures and emission measures of which were observed in the sulphur channel of the Bragg Crystal Spectromenter (BCS) onboard *Yohkoh*. The biggest flare was a C1 flare on June 19. Several of them seen as enhancements in the SXV channel had no identifications in the GOES event list, though corresponding enhancements in the 1 - 8 Åflux were all identified. The quiescent level was around A5 - A7 for about five days and the intensity of the 0.5 - 4 Å band was less than 10^{-9} Wm^{-2} (Fig. 1.)

Figure 2 is the scatter diagram of the SXV channel total counting rate vs GOES class. Triangles represents the flares observed in 1992. No flares were recorded as less than B1, because that the quiescent level seldom went below the B1-level in 1992. Large scatters might partly due to the insufficient observation coverage by *Yohkoh* and to the change of the quiescent level. A Bend of the densest ridge of triangles at the upper end indicates the saturation of the counter in the SXV channel. Filled squares for 18 events during June 1993 are overlaid in Figure 2. The deviation of squares below at the lower end can be explained by the contribution of quiescent background emissions from solar active regions. n identical interpretation of the data for the CaXIX counting rate vs GOES intensity is valid.

3. Discussions

The electron temperature is obtained by taking the ratio of the resonance line w of the helium-like sulphur to the blended feature around 5.1 Å, mostly composed of the dielectronic satellites of k and j and of the forbidden line of z (Watanabe *et al.* 1992). The integrated

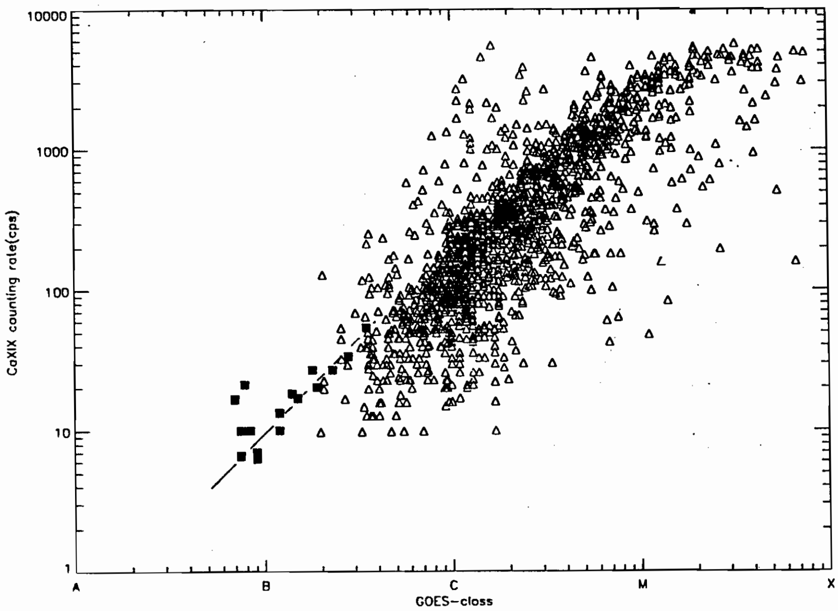

Fig. 2. Scatter diagram of the SXV total counting rate of BCS on *Yohkoh* vs. GOES intensity

line intensities are used after subtracting the background before the events. Fig. 3 shows an A-class event of June 15. It is interesting to note that like in normal flares, the maximum temperature, corresponding to the minimum line- ratio of (k+z+j)/w, is reached around 8:26 UT, well before the time of the intensity maximum around 8:40 UT.

The same analysis is applied for all the 18 events and the maximum temperatures and emission measures are obtained. Fig. 4 shows the plot of those values against the net GOES intensity class, subtracting the background contribution before the events. Theoretical synthetic simulations of the sulphur spectra with the BCS instrumental resolution reveal that the change of the line-ratio with temperature becomes small, if the electron temperature increases beyond 10 $\times 10^6$ K, and the line-ratio approaches to about 0.45. (Watanabe 1992). The average line-ratio is 0.477, which corresponds to $\sim$ 10 $\times 10^6$ K and no systematic trend of temperature decrease toward the low end. The insensitivity of the SXV line-ratio for the plasmas having the temperature above 10 $\times 10^6$ K hinders further estimates of the differential emission measure distribution in the higher temperature ranges, but one can note at least from this analysis that the characteristic of thermal plasma around and below 10 $\times 10^6$ K produced in events down to two orders of magnitude less in the GOES scale is not so different from those in normal flares greater than C1.

The maximum emission measure of events scales linearly with the GOES intensity. The least intense event during the period has a total thermal energy content of 10^{38} ergcm^{-3} and this corresponds to the thermal energy of 10^{27-28} ergs, if the electron density of 10^{10-11} cm^{-3} is assumed. It is rather difficult in this study to estimate reliable dimensions of events, because that most of them are limb-events.

Based on the study of the SXV temperatures, it can be noted that a universal differential emission measure distribution prevails in solar flares in five orders of mangnitedes, ranging from A to X10 in the GOES scale. If you include some of the data from stellar flares, the valid range extends a couple of orders more. This fact may imply that an elementary process exists for the flare energy release, meaning a sort of "an elementary burst hypothesis." Or a predominant energy transport (plasma thermalization) mechanism always gives a similar DEM distribution independent from the total amount of the released energy.

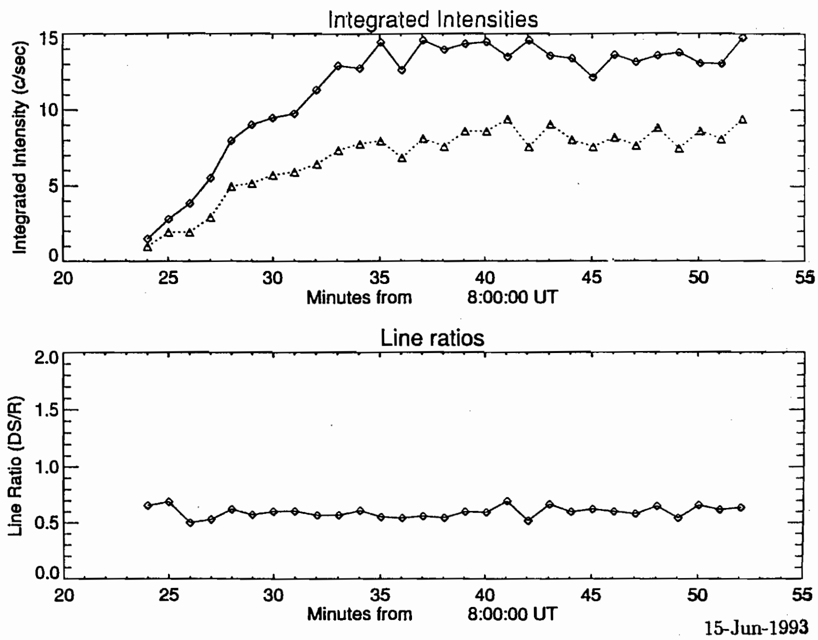

Fig. 3. Time profiles of the SXV resonance-line and dielectronic-satellite blend intensities for an A-class event on June 15, 1993

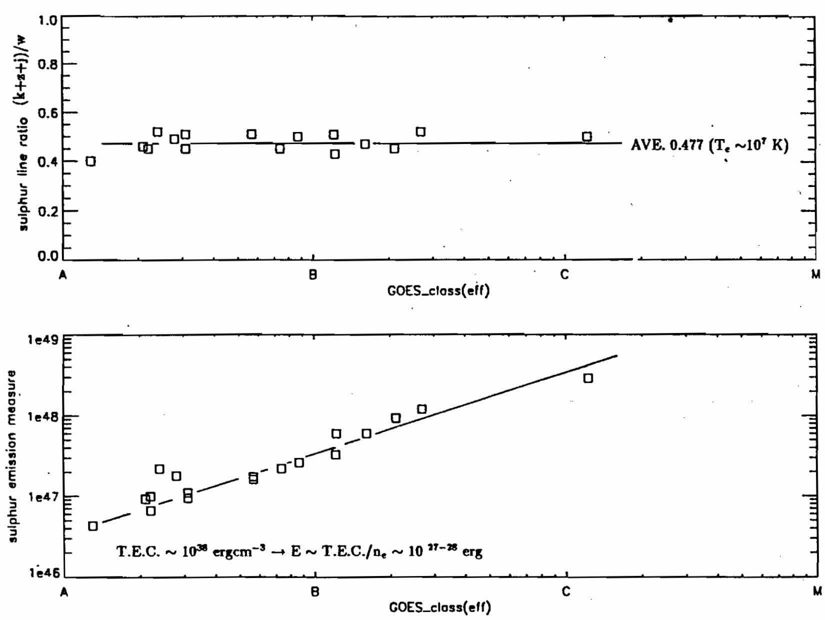

Fig. 4. The maximum temperature and maximum emission measures obtained from the helium-like sulphur lines

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