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 depend 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 Himotori. The maximum emission measure of $20 \times 10^6$ K plasmas could be easily estimated, once the GOES intensity would be known. The absolute values of the maximum temperature and the emission measure 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 occurrence frequency vs total energy diagram is required so that microflares can contribute to the coronal heating. It is observationally suggested 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 Spectrometer (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 Å flux 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
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 plasma 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 temperature 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 Cl.

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 $10^{38}$ erg cm$^{-3}$ and 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 magnitude, 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.
Microflare and Helium-like Sulphur Spectra

Acknowledgement

The successful operation of Yokkoh for more than two years in orbit is owing to all the members of the Yokkoh team. The author is grateful for Drs. H.S.Hudson, K.Shibata, and Mr. T.Shimizu for stimulating discussions. He also express his gratitude to the staffs of the Nobeyama Solar Radio Heliograph, who worked hard for the success of the symposium.

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