THERMAL AND NON-THERMAL SOFT X-RAY BURSTS

M. LANDINI, B. C. MONSIGNORI FOSSI, and R. PALLAVICINI
Osservatorio Astrofisico di Arcetri, Firenze, Italy

Soft X-ray enhancements of solar radiation are on many occasions recorded by Solrad 9 which is instrumented with several photometers sensitive to X-ray emission in the range 2–25 keV. A non-thermal interpretation of X-ray bursts for energy larger than 10–20 keV is usually given in the literature, while for the soft X-ray region below 10 keV the common interpretation is a thermal one.

In this paper some events recorded at Arcetri during the period October 1968–April 1969 are discussed in order to analyze the thermal or non-thermal nature of the events and to find indications of the energy distribution of the emitting electrons. Data from the photometers in the band 0.5–3 Å and 1–8 Å have been used.

Most of the events agree with a thermal interpretation and appear to be produced by a plasma with electron temperature between 50 and 20×10^6 K, and emission measure about 10^{48} cm^{-3}. The electron temperature slowly decreases during the decreasing phase and also near the peak; the emission measure increases during the flash phase and remains almost a constant. One impulsive event was observed on January 7, 1969, which shows a sharp decrease in temperature and increase in emission measure during the rise, and the reverse during the decreasing phase.

A non-thermal interpretation of this event was suggested by the unusual behaviour of the electron temperature. The bremsstrahlung emission is assumed to be produced by non-thermal electrons having a power law energy distribution:

$$\mathrm{d}N = KE^{-\gamma}\,\mathrm{d}E\,.$$

The values of the spectral index γ shift from 2.5 to 4 in the rising phase and back in the decreasing phase. The emission measure first increases and than decreases during the event (about one order of magnitude), but the variation is much less than that obtained by means of the thermal interpretation.

Different spectral indexes are obtained from the 1–8 Å data, but the disagreement disappears assuming that the low energy cut-off falls inside the 1.5–5 keV region. Assuming that the spectral index decreases with the collision time, as in the Fermi acceleration mechanism, and that the rise of the emission measure is due to the increasing of the electron density, both the onserved increases of the spectral index and the emission measure may be easily explained.

DISCUSSION

T. den Boggende: At wavelengths longer than say 1 Å there are a number of lines superimposed on the continuum. The contribution of lines especially during bursts or flares are not negligible. What is the influence of lines on your results of $\int N_e^2\,\mathrm{d}V$ and on T_e?

M. Landini: The computed spectrum used for the comparison includes the emission of many reso-

Space Science Reviews **13** (1972) 825–826. *All Rights Reserved*

nance lines. However the contribution of these lines for temperatures larger than 20×10^6 K is not very important. Furthermore it is necessary to remember that the data used concern broad band integrated fluxes.

T. den Boggende: What is the physical meaning of your computed temperatures?

M. Landini: In the thermal interpretation, the electron velocity distribution is assumed to be maxwellian and the temperature is that which defines such a velocity distribution.

L. D. de Feiter: It is known that it is very hard for soft X-ray events to determine whether the emission is thermal or non-thermal. What peculiarity was there in this particular event?

M. Landini: The temperature and emission measure change in the opposite way.

S. R. Kane: Your interpretation is consistent with the measurements of Kahlu and Kreplin who find that in some flare events the non-thermal electron spectrum extends down to ~ 5 keV. What are your estimates of the electron acceleration time and collision time given in your expresssion for the spectral exponent γ.

M. Landini: The values of γ obtained require acceleration times a few times longer than the collision times; collision times of a few seconds agree both with the γ values and with the expected electron density in the flare.