THE QUANTITATIVE PROPERTIES OF THREE SOFT X-RAY FLARE KERNELS OBSERVED WITH THE AS&E X-RAY TELESCOPE ON SKYLAB

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Abstract. The physical parameters for the kernels of three solar X-ray flare events have been deduced using photographic data from the S-054 X-ray telescope on Skylab as the primary data source and 1-8 and 8-20 Å fluxes from Solrad 9 as the secondary data source. The kernels had diameters of ~5-7” and in two cases electron densities at least as high as 3 x 10¹¹ cm⁻³. The lifetimes of the kernels were 5-10 min. The presence of thermal conduction during the decay phases is used to argue: (1) that kernels are entire, not small portions of, coronal loop structures, and (2) that flare heating must continue during the decay phase.

We suggest a simple geometric model to explain the role of kernels in flares in which kernels are identified with emerging flux regions. The flare is triggered at the neutral sheet between the EFR and a larger loop structure. We associate the X-ray kernels with Hα kernels, which previously associated (incorrectly, we believe) with the nonthermal impulsive phases of flares.

1. Introduction

In a study of the morphological evolution of twelve solar X-ray subflares using data from the AS&E X-ray telescope on Skylab (Kahler et al., 1975) it was found that the rise phase is characterized by the appearance of small structures (~10”) named “kernels”. That study established that kernels have lifetimes shorter than those of relatively larger accompanying structures. While faint kernels could be seen only briefly during the flare rise phase, bright kernels occasionally endured through the decay phase.

The purpose of this paper is to discuss the physical properties of a small number of X-ray kernels using quantitative parameters derived from flare images recorded on film with the S-054 grazing incidence X-ray telescope on Skylab. The S-054 data are combined with X-ray data from Solrad-9 to deduce a qualitative model for the structure of the kernel which is described in Section 4. Finally in Section 6 we suggest a simple model for the role of the kernel in the flare process.

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2. Instrumentation and Data Reduction

Flare X-ray data from two different instruments have been used in the present analysis. The primary data are in the form of solar X-ray images recorded on photographic film by the AS&E X-ray telescope on Skylab. Sequences of images were taken in which the exposures were increased for each successive image by a factor of 4, beginning with \( \frac{1}{64} \) s. Any one of six filters could be used for a sequence. A detailed description of the instrument and its operational modes is given in Vaiana et al. (1975). The other X-ray data used in the present analysis consist of whole disk measurements of broad band solar X-ray emission with nominal passbands of 1–8 and 8–20 Å made with the Solrad-9 spacecraft.

The present analysis uses the temperatures, electron densities, linear dimensions and volumes of the X-ray sources deduced from the observations. In view of the importance of these parameters with respect to the conclusions reached in this paper we will briefly describe the procedures and the uncertainties involved in determining these quantities.

For each of the flare events a number of frames of film were chosen for scanning by a microdensitometer. The resulting scans resulted in arrays of 2" by 2" elements of photographic density. The conversion from photographic density to energy flux incident on the film plane was carried out using the procedure discussed in Vaiana et al. (1975).

Figure 1 shows a comparison of the Solrad 1-8 and 8-20 Å bands and S-054 filters in their responses to flare plasmas. Calculations were done for four of the six S-054 filters and for the zero order image with the X-ray transmission grating. The S-054 filter responses were calculated using a modified Tucker and Koren (1971) spectrum and the telescope and filter efficiencies. The Solrad responses were calculated by Dere et al. (1974a) using line spectra from Tucker and Koren and continuum calculations of Culhane (1969). Since the 1-8 Å detector is more temperature sensitive than any of the S-054 filters and the 8-20 Å detector is more comparable to the S-054 filters, the hotter plasmas will be more important in the temperatures and emission measures derived from the Solrad measurements than in the fluxes we measure with the S-054 flare images. If we assume that the emission measure distribution of the flare decreases with temperature (Dere et al., 1974b), then the effective emission measure we derive from the 1-8 and 8-20 Å bands will be smaller than the effective emission measure contributing to the size of the S-054 images. Therefore, using size measurements from the S-054 data and emission measures from the Solrad data will result in a lower limit for the electron density.

One of the objectives of the present study is to measure the intrinsic sizes of the X-ray sources. This is done by deconvolving the effect of the telescope point spread function from the measured image size. Computations of the convolution of the point spread function with various Gaussian X-ray source distributions were carried out. The result was a relationship between the Gaussian width of the X-ray image and the Gaussian width of the X-ray source.