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Imaging with the Scanning Sky Monitor on ASTROSAT

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Abstract. This paper describes the status of the development of software for coded mask imaging with the Scanning Sky Monitor aboard the proposed Indian multiwavelength astronomy satellite ASTROSAT.

Keywords : X-ray astronomy – all-sky monitor – coded mask imaging

1. Introduction

The proposed Scanning Sky Monitor (SSM) on board the ASTROSAT is an assembly of three coded mask cameras mounted on a rotating boom for scanning the sky (Seetha et al 2002). Each of these cameras consists of a detector with eight parallel position sensitive anode wires. This is a one-dimensional detector system with position information for the photon strikes available along the wires.

The coded mask has been designed to utilise this position sensitivity along the anode wires to provide a good angular resolution (about 10 arcmin) in the wire direction. Comparable resolution in a direction normal to this will be obtained by using a second camera in the assembly.

2. The Mask for the SSM

A coded mask camera works by locating the shadow of the mask cast by the source on the detector plane. The shift of the shadow with respect to the position expected for normal incidence encodes the angle of the source with respect to the camera normal. A cross correlation of the recorded shadow pattern with the mask is normally used to recover this shift, and hence infer the location of the source.

There are two main constraints placed on the mask design. In order for the reconstruction to be unique, the mask pattern is required to have an autocorrelation function with a single peak and perfectly flat sidelobes. Second, in order to collect as many photons as possible the mask should have a fairly large open fraction. For the ASTROSAT SSM we have adopted a 63-element pseudo-noise Uniformly Redundant Array pattern (Caroli et al 1987), with $\sim 50\%$ open fraction. A mask element is an elongated slit, with a dimension of ~ 0.9 mm in the coding direction (along the anode wires) and ~ 125 mm across it.

3. Image reconstruction

Since the dimension of the mask plate in the coded direction is the same as the detector wires, the field of view is partially coded except for normal incidence. For image reconstruction in this case we adopt the cross-correlation technique for "box-type camera" described by in't Zand (1992). The counts recorded by the wires are binned in cells of size equal to a mask element, and the sky within the field of view is divided into "sky elements", where the separation between successive sky elements corresponds to the shift of the shadow of the mask by one detector bin. For each sky element the relevant portion of the mask and the detector bins are identified. The counts in these detector bins are cross correlated with the relevant portion of the mask pattern and normalised by the number of open elements in that mask section. A similar normalised cross correlation, obtained with the complement of the mask pattern, is then subtracted from it. This procedure is repeated for all sky elements. As the relevant portion of the detector for a sky element partially overlaps with that for others, the resultant cross-talk generates a "coding noise" which can be modelled and largely removed by iterative identification of sources and subtraction of their expected response.

We have extensively tested this procedure with computer simulations of the response of the Scanning Sky Monitor, and have demonstrated the source location capability. The presence of eight detector wires and six different mask patterns adds a limited source location capability also in the non-coded direction. This works on the principle that the signal-to-noise ratio of a given source after adding images reconstructed independently from the eight different anode wires is maximised if the correct combination of the mask pattern and wire numbers have been used. The identification of correct mask/wire combinations allows one to distinguish between 55 different directions within the non-coded field-of-view. The final angular resolution obtained will therefore be $\sim 10' \times 2^\circ$ for a single camera, within a field of view of $\pm 11^\circ \times 90^\circ$.

References

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