THE SOFT X-RAY TELESCOPE FOR THE SOLAR-A MISSION*

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Abstract. The Soft X-ray Telescope (SXT) of the SOLAR-A mission is designed to produce X-ray movies of flares with excellent angular and time resolution as well as full-disk X-ray images for general studies. A selection of thin metal filters provide a measure of temperature discrimination and aid in obtaining the wide dynamic range required for solar observing. The co-aligned SXT aspect telescope will yield optical images for aspect reference, white-light flare and sunspot studies, and, possibly, helioseismology. This paper describes the capabilities and characteristics of the SXT for scientific observing.

1. Introduction

The Soft X-ray Telescope (SXT) will provide, for the first time, the opportunity to image the Sun in X-rays over a long period of time with both high temporal and spatial resolution. It gives SOLAR-A an important capability for solar science beyond the study of flares, the primary objective of the mission. The SXT instrument was jointly developed by the Lockheed Palo Alto Research Laboratory and the National Astronomical Observatory of Japan. Collaborators include the University of Tokyo, Stanford University, the University of California at Berkeley, and the University of Hawaii.

The SXT instrument that makes the observations in support of our scientific objectives is a glancing incidence telescope of 1.54 m focal length which forms X-ray images in the 0.25 to 4.0 keV range on a 1024 × 1024 virtual phase charge coupled device (CCD) detector. A selection of thin metallic filters located near the focal plane provides the capability to separate different X-ray energies for plasma temperature diagnostics.

* After the launch the name of SOLAR-A has been changed to YOHKOH.
Knowledge of the location of X-ray images with respect to features observable in visible light is provided by a coaxially mounted visible-light telescope which forms its image on the CCD detector when the thin metallic filter is replaced by an appropriate glass filter.

The ability of the instrument to perform its observational tasks to the levels necessary to achieve our objectives is highly dependent on the optical performance of the X-ray mirror and the quality of the CCD detector. Other determining factors are the stability of the metering structure and the quality of the instrument calibration. Finally, versatility of instrument control and discriminating utilization of limited telemetry are key to the success of the experiment.

1.1. SCIENTIFIC OBJECTIVES

Soft X-ray images reveal the distribution of high-temperature coronal gas and, thus, the structure of the confining magnetic field and thus the topological context of solar activity. SOLAR-A will, for the first time, provide simultaneous soft and hard X-ray images with good angular and temporal resolution. The SXT X-ray images will be searched for the following kinds of information:

- The geometry of the X-ray emitting structures and the inferred coronal magnetic field topology;
- the temperature and density of X-ray emitting plasma;
- the spatial and temporal characteristics of flare energy deposition;
- the transport of energetic particles and conduction fronts;
- the presence of waves or other magnetic field disturbances associated with sprays, filament eruptions, and coronal transients; and
- the locations of energy release and particle acceleration.

The SXT will, by itself, contribute new insights into solar physics. Yet, many studies will benefit from study of correlated observations made with all the SOLAR-A instruments and simultaneous observations made with ground-based solar radio and optical telescopes. Concrete steps have been taken (e.g., Morrison et al., 1991) to facilitate joint analysis of different types of solar observations. The primary objective of the SOLAR-A mission is flare research. SXT will contribute to answering the questions of the following type:

- Are there observable pre-flare conditions which give rise to an energetic flare?
- Are there observable discriminators between flares with strong nonthermal effects, e.g., high-energy particle acceleration and mass ejection, and those that exhibit primarily thermal properties?
- Is flare energy released continuously or in discrete pulses (elementary flares)?
- What is the filling factor of coronal and flare loops?
- What is the characteristic time for the acceleration process?
- Are electrons and ions accelerated simultaneously by the same process? Are there multiple phases or steps in the acceleration process to cover the wide range of energy (non-relativistic to relativistic) and mass (electrons, protons, and heavier ions)?
- Are there observational clues to the location and dimensions of the acceleration