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Science from "Solar X-ray Spectrometer (SOXS)" - Proposed payload onboard Indian satellite

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Abstract. It is proposed to fly a high spectral and temporal resolution "Solar X-ray Spectrometer (SOXS)" onboard Indian satellite to understand the mechanisms of energy release and particle acceleration in solar flares. The SOXS will provide the disk integrated flux in the energy range 2 keV-10 MeV. The proposed SOXS will consist of two detector modules - SOXS Low Energy Detector (SLD) and SOXS High Energy Detector (SHD). The proposed instrument will enable us to measure precisely the low energy cut-off below 60 keV to estimate the total energy release in the flare. It is proposed that high spectral and temporal resolution efficiencies of our detectors will reveal, perhaps for the first time, the observed break below 60 keV in the characteristic double power-law shape of hard X-ray spectrum. Whether electrons and protons are accelerated simultaneously may be also answered by correlating high temporal spectra of SLD and SHD. The high temporal and sub-keV resolution spectra from SLD will be capable to investigate the nature of micro/nano flares considered responsible to heat the chromosphere and corona. It is proposed to use the observations from this space borne instrument, along with extensive simultaneous ground based high spatial and time resolution observations in optical and radio wavebands for better understanding of the flare phenomena.

1. Proposed study

We propose to study various energy processes in solar flares in the energy range 2 keV-10 MeV with a time resolution of 10 ms, using a space borne experiment - "Solar X-ray Spectrometer (SOXS)" on-board Indian satellite. The proposed study involves several energetic phenomena, such as; rapid release of energy stored in an unstable magnetic field configuration, equally rapid

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conversion of this energy into kinetic energy of accelerated particles and hot plasma, transport of these particles and plasma, and the subsequent heating of the ambient solar atmosphere. Observations of hard X-rays and gamma rays serve as the best diagnostics of these processes by providing direct evidence for the interaction of accelerated particles in solar flares. However, the spectral and temporal resolving powers must match the spectral and temporal scales that characterize the processes of energy release, acceleration, and transport. The sensitivity should be high enough to detect the initial energy release and particle acceleration, and also to provide observations over a wide range of intensities from microflares to large flares. The SOXS experiment proposes to make full disk integrated observations of the Sun using a Silicon PIN detector in the 2-15 keV range; Cadmium-Zinc-Telluride (CZT) detector in the 4-100 keV range and a NaI (TI)/CsI (Na) phoswich detector in the 15 keV-10 MeV range. It is proposed that the SOXS experiment will be included in one of the Indian Satellites, preferably on GSAT-2 or 3, which are expected to be launched in 2000-01, during the sunspot maximum period (Jain, 1997).

2. Expected science

(i). The proposed experiment will allow measurements in the 2-100 keV range with sub-keV energy resolution, and 5 keV resolution in the energy range 15 keV-10 Mev with high time resolution (~10ms). This will enable us to understand the physical processes of time evolution of energy release, particle acceleration and transport of energy taking place at various phases of a flare (Lin et al., 1981). It will further allow us to quantify precisely the energy budget in pre/post phases of impulsive and gradual solar flares, particularly in context to different phases of thermal and non-thermal flares.

(ii) High Spectral energy resolution (<1keV) will allow to differentiate the thermal and non-thermal components of flares in low energy (2-100 keV) or even identify complex distribution like κ distributions (Hagyard et al., 1990).

(iii) The measurement of X-ray flux at various stages of a flare below 100 keV will allow us to determine the super-hot component in flares which is in debate at present. The measurement of the low energy cut off will help to estimate the total number of electrons accelerated and hence the total energy released.

(iv) Break in the energy spectrum (Hollman and Benka, 1992) will provide measure of the maximum potential drop and thereby help to understand the change in power-law from thermal to non-thermal component, which is yet in question.

(v) High spectral and temporal resolution observations will allow to measure the millisecond periodic nature in HXR spectrum, similar to that observed in microwave, which in turn may enable us to investigate whether the energy release in flares is a continuous or a discrete phenomena during the flare interval. This study will be extended to look for correlation between HXR oscillations and Hα intensity oscillations in flare kernels, recently detected by Jain and Tripathy (1998), which are the seats of non-thermal HXR emissions.

(vi) The time evolution of gamma ray spectra (500 keV-10 Mev) and their respective delay as a function of energy will enable us to determine the particle acceleration characteristics and energy deposition in the solar atmosphere (Hudson and Dwivedi 1982). The comparison of SLD and SHD spectra will help to understand the mechanisms of acceleration of low and high energy charged particles in solar flares.

(vii) The sub-keV energy resolution will enable to quantify the global contribution of micro/ nano flares in heating the chromosphere and the corona (Lin et al., 1984, Shimiju et al., 1994).

(vii) The proposed space-borne observations from SOXS along with extensive simultaneous high spatial and time resolution ground based observations in optical and radio wavebands will allow better understanding of the flare phenomena.

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