High Energy X-ray Spectrometer (HEX) On-board Chandrayaan-1

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Introduction

The High Energy X-ray (HEX) spectrometer experiment Chandrayaan-1 is designed to detect the hard X-rays emitted from the lunar surface in the energy range of 30 – 270 keV. This energy range contains many characteristic low energy γ–ray lines from naturally occurring radio-active elements in the lunar surface such as U, Th and their decay products. However, due to the lack of suitable detector as well as the anticipated high planetary continuum background this energy range has been completely unexplored so far in planetary studies. With the development of new solid state array detectors it is now possible to explore this energy region and HEX is the first experiment to carry out spectroscopic studies of lunar surface at hard X-ray energies.

Scientific Objective

The primary scientific objective of HEX is to investigate the volatile transport phenomena, which is assumed to be the responsible for accumulation of water in the polar cold traps of lunar surface. The HEX experiment is designed to study this phenomenon through the detection of 46.5 keV characteristic line or ^{210}Pb, which is a decay product of ^{222}Rn, both belonging to ^{238}U series. The ^{222}Rn is a volatile and is expected to undergo volatile transport and get accumulated in polar cold traps similar to water molecules. Thus any enhancement in the emission of the 46.5 keV γ-ray line in the polar region can provide evidence of the hypothesized volatile transport phenomena. The secondary objective of HEX is to obtain low spatial resolution U and Th map of the polar and U-Th enriched (e.g. KREEP) regions, using other characteristic lines from ^{234}Th (63.3, 92.4 and 92.8 keV), ^{226}Ra, ^{235}U (186.2 and 185.7 keV) and $^{212, 214}$Pb (238.6 and 214.9 keV).

Instrument Configuration

HEX is designed using Cadmium-Zinc-Telluride (CZT) array, which is the state-of-the-art semiconductor X-ray detector. The geometric detector area of 144 cm^2 is realized by arranging nine Cadmium-Zinc-Telluride (CZT) arrays, each of area 4 cm x 4 cm and 5 mm thick and composed of 256 (16 × 16) pixels (size: 2.5 mm × 2.5 mm). The CZT crystals are coupled with a multi-channel read out ASIC (Application Specific Integrated Circuit). HEX also employs another X-ray detector based on CsI(Tl) as an anticoincidence (ACS) detector, in order to reject the partial energy deposit events. Field of view of HEX is restricted to 33 × 33 km using a stainless still collimator.

Present status

After the successful launch, the expected instrument performance of HEX was verified during the commissioning phase of Chandrayaan-1 in December 2008. The scientific operation of HEX was planned only the periods known as non- imaging season period of three months duration occurring twice a year. Here we present preliminary results form the data acquired during the first scientific operation season of HEX which occurred from February 2009 to April 2009. Due to the detector temperature constraints, HEX was operated for about 4 – 6 orbits per day covering the polar regions of the Moon. The resultant useful exposure time is approximately 40 hours, which is less then the integration time required to detect the γ-ray lines from the lunar surface. However, the continuum background observed by HEX agrees fairly well with the background expected from the Monte-Carlo simulations, if some post launch gain changes is assumed. It should be noted that this is the first measurement of hard X-ray background from the Moon.