Abstract: This paper presents a solar X-ray monitor (SXM) boarded on Chang’E2 (CE2)satellite which was lifted off by the rocket CZ2 on Oct.1 2010 by Chinese Space Agency. The SXM payload consists of three parts, including silicon detector, frontend electronics and data acquisition unit based on microprocessor 80c196. The solar X-ray monitor is used to monitor sun activities in step with a dedicated lunar X-ray spectrometer which is boarded on CE2 as well and explores simultaneously characteristic fluorescent X-ray from moon surface soil. Those data of the SXM are used as input function spectrum to de-convolute the data information of the dedicated CE2’s lunar fluorescent X-ray spectrometer. Meanwhile, more than 700 solar X-ray flares observed by the SXM because it happened to meet the solar flares actively of cycle 24, at the same time, the SXM was coordinating with the dedicated CE2’s lunar X-ray spectrometer operation each other. The high-resolution data based on the SXM can be used to investigate the solar physics and astrophysics such as X-ray emission of CME, the coronal plasma temperature, particle acceleration processes, and X/γ-ray astronomy as well. The SXM’s performances, operating principle, system configuration and some of exploration results are described in this presentation.

Keywords: Solar X-ray Monitor, Chang’E2 Satellite, Solar X-ray Flares

1 Introduction
The solar X-ray monitor (SXM) is an element of the payloads of CE2 satellite, which was lifted off by the rocket CZ2 on October 2010. It worked effectively for 190 days from 15 October 2010 and had satisfactorily function. Due to sun active rise period of cycle 24, SXM collected more than 700 flares of A1.0 to X1.4 in the used GOES classification. The data analysis results show that the SXM possesses excellent performance and great promise for investigating solar flares and coronal mass ejections, except for as an input spectra applied to data analysis of the dedicated lunar fluorescent X-ray spectrometer[1]. In this presentation, we shall introduce the CE2/SXM’s instrument configuration, operation principle and its in-orbit performance as well as some of its observation results.

2 Solar X-ray Monitor of CE2
SXM Detector
The CE2/SXM instrument consists of the state-of-the-art detector, front end electronics and data acquisition system as shown in Fig.1. The detector used a 500um thick silicon PIN photodiode(Si-PIN) with the internal cooling device, which contributes superb high energy resolution of less than 300 ev at 5.95 keV in the energy range from 0.5keV to 10keV. It has a 5° field of view with the special collimator. For its well operation, the detector bias voltage about 70 volts is supplied by a high voltage generator.

SXM Electronics
The SXM electronics are designed to have low noise and good stability over the wide range of temperatures that SXM will encounter. The electronics system comprises two sections, one is front end including a charge-sensitive amplifier and a shaping amplifier, which is ganged with the Si-PIN in order to reduce a noise picked up by a connection, another one is split in the board of data processing, bus interface and the high voltage generator. Fig.1(c) shows the function block diagram for solar X-ray monitor electronics. The incident X-ray from solar flare was fed into the Si-PIN detector and sensed by interacting with silicon crystal as a result of charges derived from both holes and electrons. Those charges are collected and amplified to form a voltage signal at output of the Charge Sensitive Amplifier (CSA). The voltage signal height is proportional to the relevant incident X-ray energy. Their wide dynamic range and excellent noise performance of allow SXM to detect energy depositions in Si-PIN as small as 500eV and as large as 10keV. The output of the preamplifier is split into two branches, one branch goes to a Peak-Hold (PH) circuit and subsequently to an Analog-to-Digital Convertor (ADC), the other to a Single Channel Analyzer (SCA), which consists of two discriminators with low threshold and up threshold respectively. The two outputs of the SCA are passed to an input of micro-Controller (uC) of 80c196 and to an input of an Counting-Rate-Meter (CRM) operated via the uC. When the input signal of SCA is big enough over the low threshold and resides between the low and up threshold, the uC is triggered by the output of SCA and initiates ADC to start conversion. Meanwhile, based on the processing program of CE2/SXM in a Read Only Memory (ROM), the uC proceeds ADC data and reads contents of CRM counter and saves them into data memory, then packages these data along a certain coding format. The uC sends these data to a ground station via 1553B bus.
Fig. 1: (a) the solar X-ray monitor of Chang’E2. (b) the electronics box for whole system of the lunar and solar X-ray payload, the second slot from left side is the solar x-ray electronics board. (c) the function block diagram for solar X-ray monitor electronics.

3 Some Observation Results and Discussion

The solar X-ray monitor with CE2 satellite was lifted off by the rocket CZ2 on 15 October 2010 and was due to start its observation. Since then, the SXM obtained more than 700 flares of A1.0 to X1.5 in the GOES classification. Fig 2 illustrates the spectral evolution of the March 1, 2011 flare event. It is seen that a light curve profile of the flare is consistent in the GOES observation to the same event. Moreover, it is supported that CE2/SXM’s performance and function is satisfactory.

Fig. 3: Spectral evolution of a solar flare in soft X-ray waveband seen by CE2/SXM on 31 October 2010.

As shown in Fig 3, the CE2/SXM’s unprecedented high spectral resolution (less than 300eV) has revealed distinctly separate Fe and Fe/Ni line feature, which appear during solar flares and peak at 6.7 and 8 keV respectively. Based on the good spectral observations of many flares, it is suggested that the peak energy and equivalent width of the Fe-line feature varies with flare plasma temperature, as shown in Fig 4. The X-ray and \( \gamma \)-ray observations from space from the 1960s revealed that solar flares begin with high energy processes [2, 3]. The dominating components that make the solar X-ray corona very dynamic are accelerated particles, the evaporation of large masses of high-pressure plasma into coronal magnetic loops, and magnetic eruptions. When the magnetic energy that has built up in the solar atmosphere is suddenly released, a solar flare raises. Therefore, this is also a multi-thermal power law process and temporal flare evolution is energy-dependent as observed in Fig 4. This flare’s intensity is a function of energy at four different time intervals and possess a heating-cooling-heating process of solar corona in the solar atmosphere during around 8 seconds. CE2/SXM’s Data analysis and further work is in progress. Some of scientific results will be published in the near future.

Fig. 4: The spectra and profiles in energy band from 1 to 10 keV of the 16 October 2010 M2.98 flare.

4 summary

SXM is an element of payloads of CE2 satellite and worked satisfactorily. It obtained more than 700 flares and delivered significant scientific finding. In this presentation, we have described CE2/SXM construction, function and performance as well. The author express his sincere thanks to the Assembly of Lunar and Deep Exploration of Chinese Academy of Sciences (CAS), the Key Lab. of particle astrophysics and Institute of high energy physics of CAS, and Chinese Space Agency for providing such a nice opportunity to participate the lunar observation and solar studies.

References

Fig. 2: CE2/SXM observing result in agreement with the GOES satellite result.