Solar flare observations with Chandrayaan-2 Solar X-ray Monitor

B.S. Bharath Saiguhan*, N.P.S. Mithun, Santosh Vadawale, C.S. Vaishnava, Biswajit Mondal

*e-mail: bsg@prl.res.in

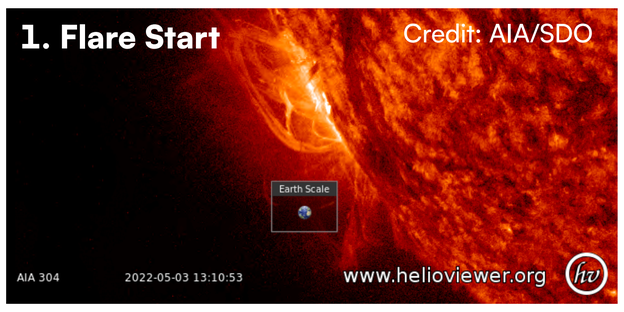
Physical Research Laboratory, Navrangpura, Ahmedabad - 380058

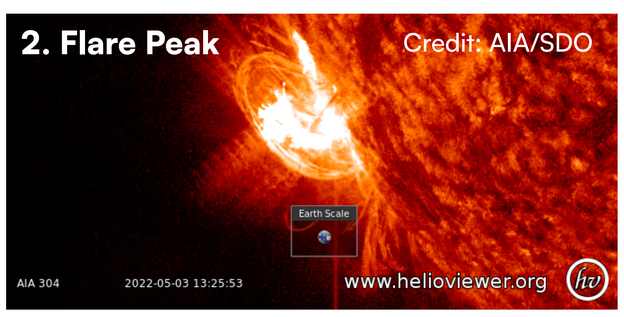
Introduction

Solar flares, outbursts of electromagnetic radiation from the Sun's atmosphere, are among the most energetic phenomena occurring in the Solar system.

Solar flares are events of prime interest in the field of space weather, due to the X-ray and extreme ultraviolet radiation output by them which have the capability to affect global communication systems.

Solar flares are also intimately linked with the physical processes of the Sun since they occur in Active Regions, and are (sometimes) accompanied by **Coronal Mass Ejections**, **Solar Particle Events** and other phenomena.
Thus, studying them shines light on both the Sun as a star, as well as helps inform space weather forecast models.



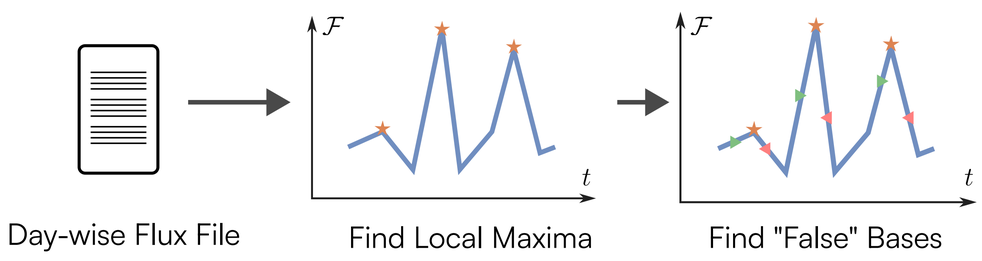


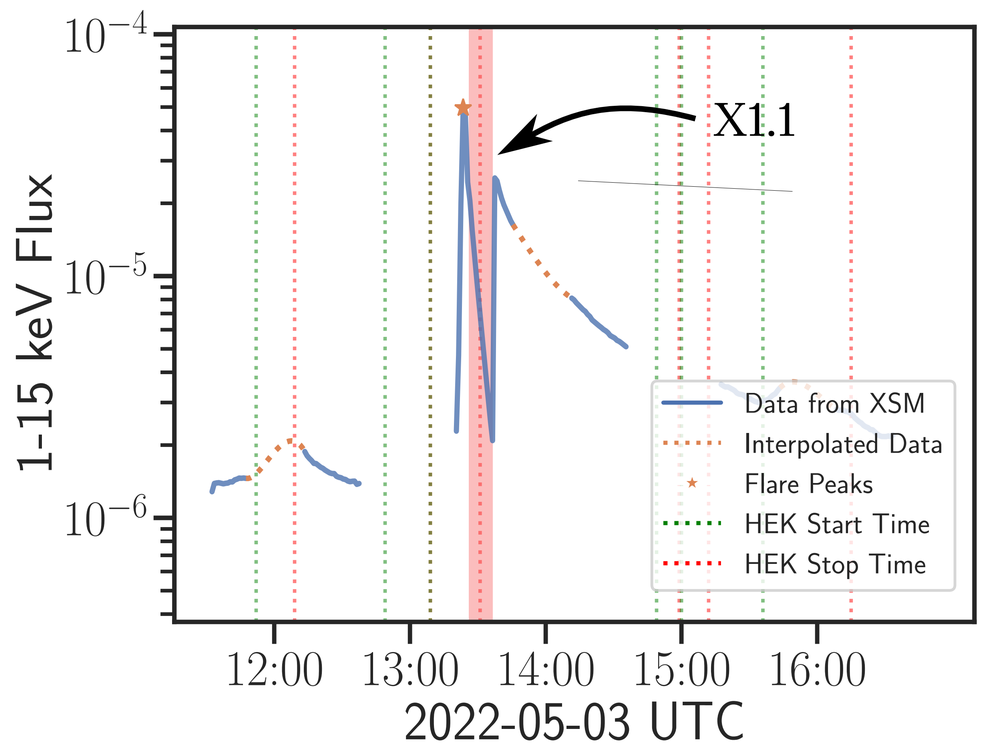
The **Solar X-ray Monitor** (abbreviated as **XSM**) is a part of the remote X-ray fluorescence spectroscopy experiment on board the **Chandrayaan-2** mission to the Moon, and observes the Sun as a star.

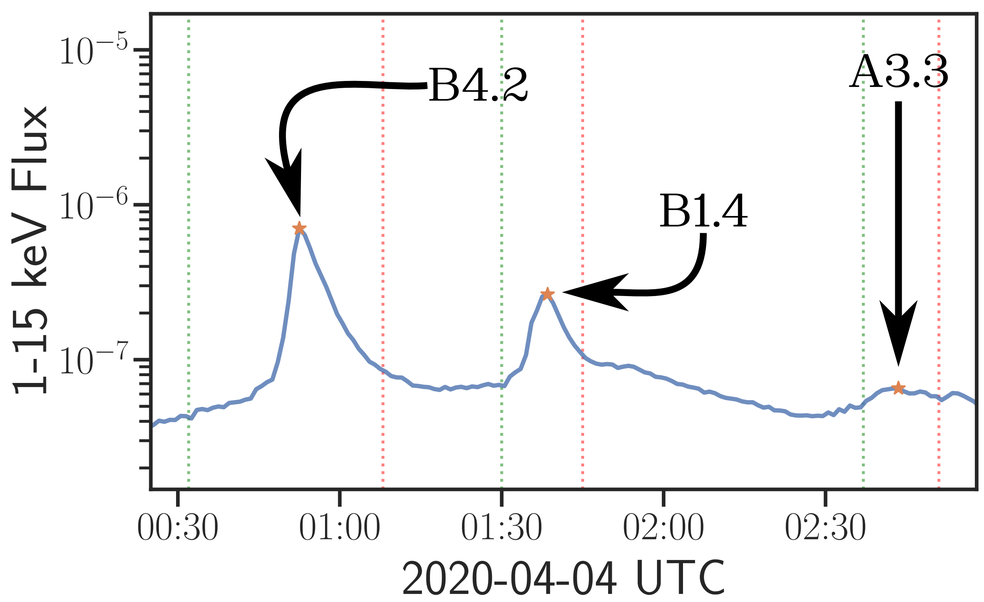
XSM measures the solar X-ray spectrum in the **energy range of 1–15 keV** with an **energy resolution of ~ 175 eV at 5.9 keV** and a **time cadence of one second**.
The broadband soft X-ray spectra with XSM provides diagnostics of the solar corona at various levels of solar activity from quiescent Sun to large solar flares.

Methodology

We developed a Python program to analyse the ~4 year X-ray flux data from XSM to look for flares.
The program takes as input day-wise flux files, and outputs a text file containing the time and peak flux for all flares detected during that day.
This was achieved as follows:







Solar flares found according to the above method were cross-matched (in time) to flaring events reported by **Solar Dynamics Observatory (SDO)/AIA** + **Geostationary Environmental Operational Satellite (GOES)/XRS** in the **Heliophysics Event Knowledgebase (HEK)**.
A **user queryable database** of all such XSM-detected solar flares will soon be made available as part of the existing **web-based UI.**

https://www.prl.res.in/ch2xsm

Results

~4 year X-ray flux data → (~10 min.) → ~4000 flares

Solar flares from **< A to > X GOES class were detected** with the software developed, and statistical studies of solar flares are underway using this data.

Furthermore, this **flare detection methodology is being incorporated into the XSM Payload Operations Center (POC)** data pipeline.
This will ensure a regularly updated flare database (allowing time for human vetting), with **details for newly detected solar flare events**.

Future Work

The flare detection software architecture developed here was made to be as mission agnostic as possible, which means that the same architecture can be reused (after minor tweaks) for future X-ray Solar observatories as well, such as for the **Solar Low Energy X-ray Spectrometer (SoLEXS)** and the **High Energy L1 Orbiting X-ray Spectrometer (HEL1OS)** instruments to be sent as part of **Aditya-L1**.

The current architecture is also being extended to **also detect flare start and stop times**.
This then informs long term parameter estimation studies across the full duration of flares, using standard X-ray analysis software (**such as XSPEC**).

Additionally, it is planned to release the current architecture under an **open source license** after sufficient testing and maturity.
The **code base is also well documented** and design choices are spelled out, so that it can be extended by a power user, or the Solar physics community at large.

References

1. Mithun, N. P. S. et al., "**Solar X-ray Monitor On board the Chandrayaan-2 Orbiter: In-flight Performance and Science Prospects**", *Solar Physics* , 295:139, 2020.

2. Shanmugam, M. et al., "**Solar X-ray Monitor Onboard Chandrayaan-2 Orbiter**", *Current Science*, 118(1):45, 2020.

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