Thermal characteristics of a B8.3 flare observed on July 04, 2009

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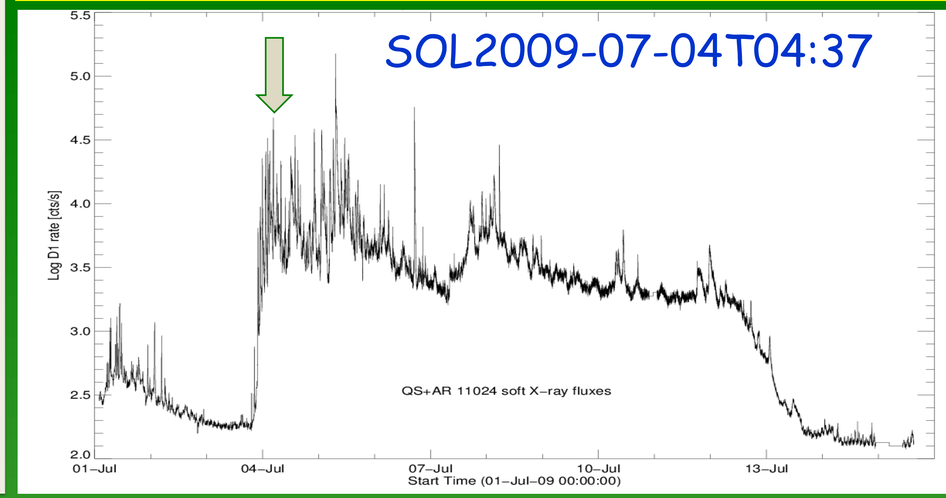
ABSTRACT

We explore the temporal evolution of flare plasma parameters including temperature (T) – differential emission measure (DEM) relationship by analyzing high spectral and temporal cadence X-ray emission in 1.6-8 keV energy band, recorded by SphinX (Polish) and Solar X-ray Spectrometer (SOXS; Indian) instruments, during a B8.3 flare. SphinX records X-ray emission in 1.2-15 keV energy band with the temporal and spectral cadence as good as 6μs and 0.4 keV, respectively. On the other hand, SOXS provides X-ray observations in 4-25 keV energy band with the temporal and spectral resolution of 3s and 0.7 keV, respectively. In addition, we determine the EUV flaring kernel shapes in 171, 194 and 284 Å obtained from STEREO mission in order to explore the variation of flaring plasma volumes. Thermal energetics are also estimated using geometrically corrected flaring loop structure obtained through EUV images of the active region from STEREO twin satellites.

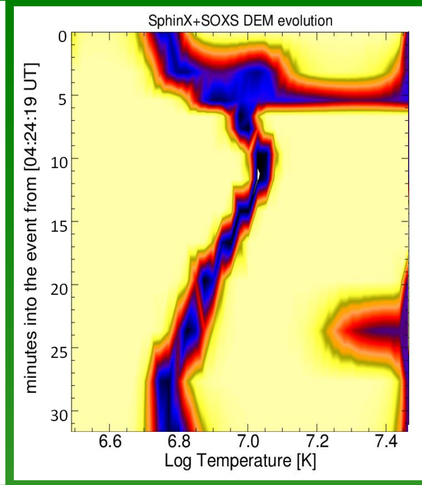
Introduction

- Thermal characteristics of solar flare plasma employing the observations covering the span of EUV to X-ray waveband is of immense interest as it can shed light on the ongoing coupling processes in solar atmosphere.
- Temporal and spectral evolution of flare plasma parameters viz. temperature and emission measure employing the observations from SphinX (Gburek al. 2013), SOXS (Jain at al. 2011) and STEREO Twin missions (Howard et al. 2008).
- SOL2009-07-04T04:37, selected for present analysis is the only event common between SOXS and SphinX. The event occurred in active region 11024 born on the disk on 3 July. This single AR rotated off the disk on 15 July 2009. More than 500 events i.e. flares or small brightenings have been identified on the soft X-ray lightcurve during that time. The history of X-ray activity of this AR, as seen through the eyes of SphinX is illustrated in the adjacent Figure.

X-Ray light-curve of AR 11024 as seen by SphinX

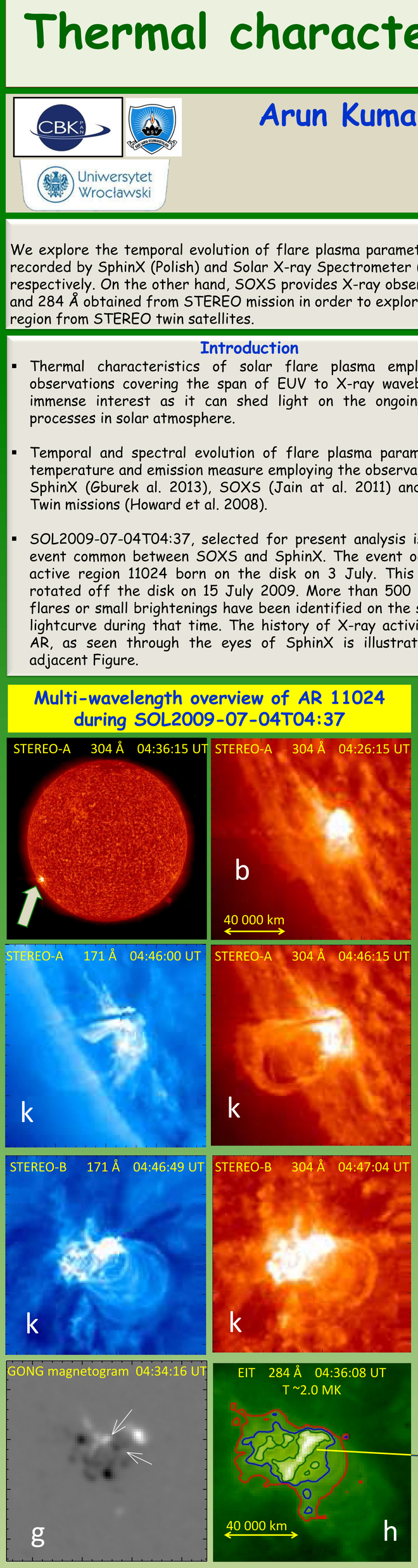


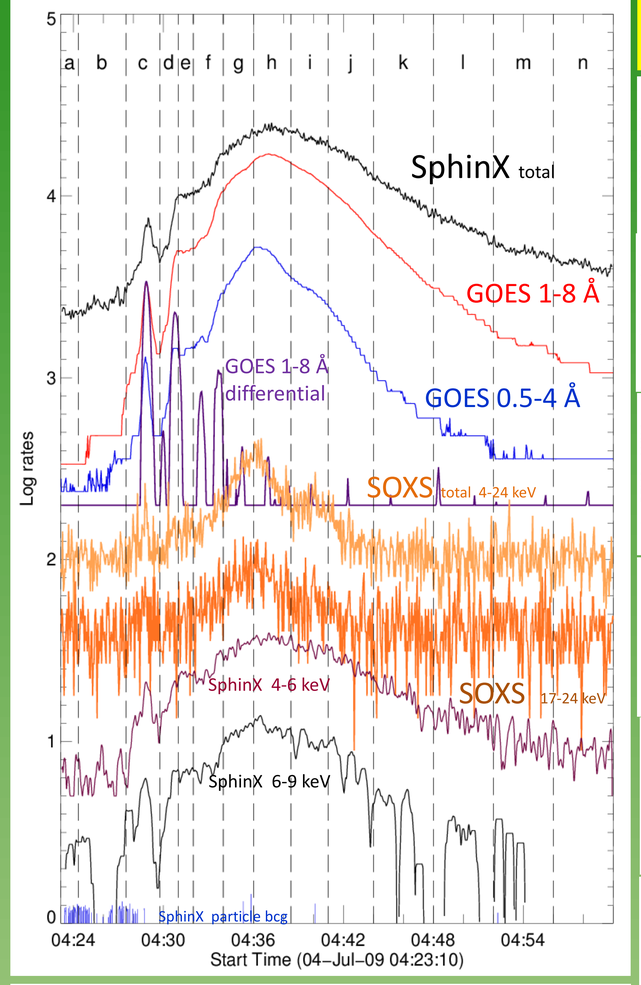
Evolution of DEM distribution vs T in the range of 3-30 MK

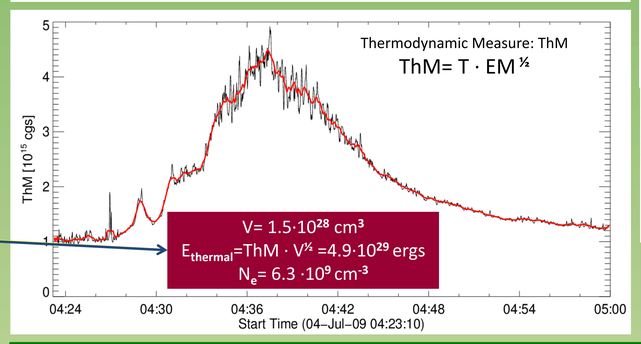


- ✓ Individual DEM profiles were calculated using both SphinX (1.6-5 keV) and SOXS (5-8.0 keV) spectra.
- ✓ The normalization factor (2.5) was used in order to accommodate for a systematic difference of sensitivities between the instruments.
- ✓ Coronal abundances were adopted when calculating theoretical dependence of spectral shapes.
- ✓ DEM inversion was performed using the maximum likelihood routine of Withbroe-Sylwester (Sylwester et al. 1980).

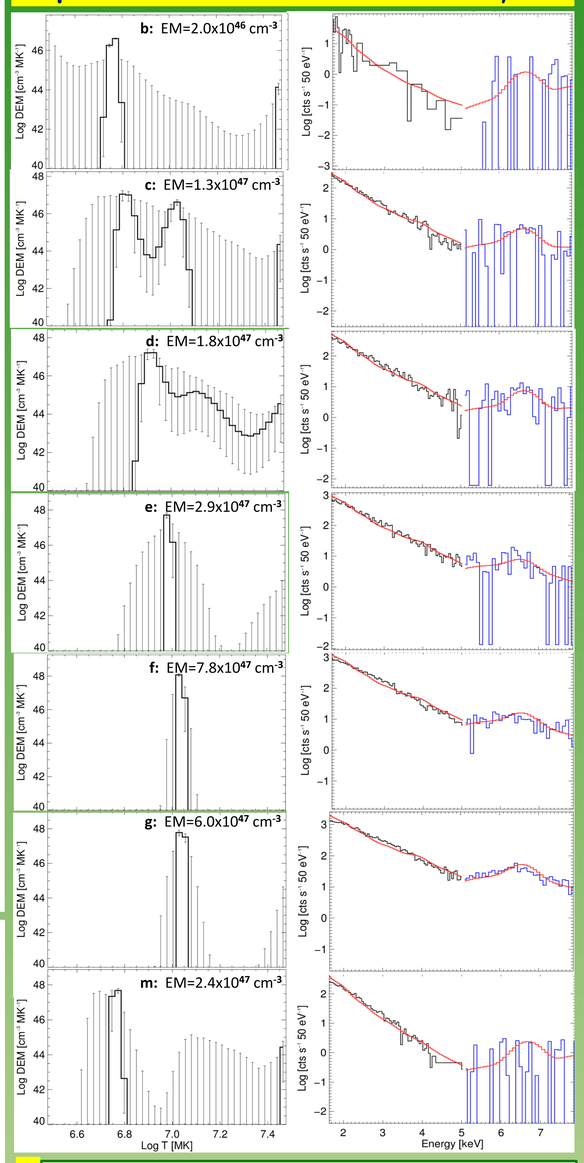
Multi-wavelength overview of AR 11024 during SOL2009-07-04T04:37







Optimum Fit as resulted from SphinX-SOXS combined DEM analysis



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Gburek et al. 2013, Solar Physics, Volume 283, Issue 2, pp.631-649
Hannah and Kontar, 2012, Astronomy & Astrophysics, Volume 539, id.A146, 14 pp.
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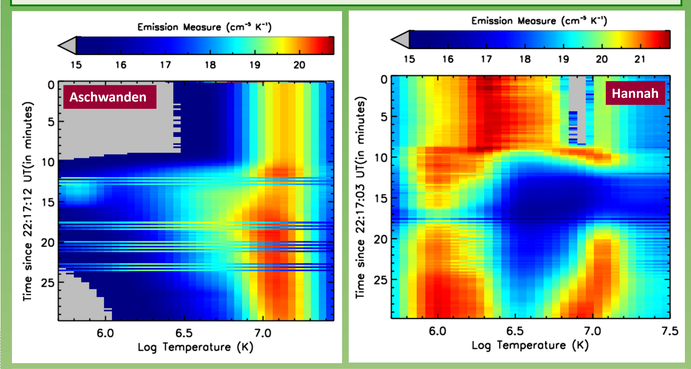
Sylwester et al., 1980, Solar Physics, vol. 67, Sept. 1980, p. 285-309.

Summary & Discussion

1. We have analyzed SOL2009-07-04T04:37 and determined temporal evolution of DEM vs T over the flare duration.
2. During flare onset time (refer 'b' in the light curve), the best fit DEM can be nearly approximated by single Gaussian function of T (width ~1 MK), which suggests flare plasma to be nearly isothermal in this duration.
3. On the contrary, during the rise of the impulsive phase of the flare (refer 'c' and 'd'), best-fit DEM (T) curves resemble double Gaussian function with increased widths ~ 1.5 MK (in comparison to that in 'b'). This reveals the signature of multi-thermal plasma in this phase.
4. The DEM evolution for the rest of the time intervals considered in this study result in single Gaussian function of T, however, with varying peak temperature.
5. **Comparison with other T-EM synthesis techniques:** We made a comparative study of EM - T relationship determined employing current technique with other methods proposed by Aschwanden et al. (2013) and Hannah and Kontar (2012). In this regard, we studied SOL2010-11-15T22:30, another solar flare occurred in SDO observing era, however, of the same (B8.3) GOES X-ray intensity class. Co-temporal AIA/SDO observations in six EUV channels viz. 94, 131, 171, 193, 211 and 331 Å are used to determine EM and T over the flare duration.



The aforesaid exercise enabled us to understand that:

- ➢ These two techniques provide an incomplete picture of the T-EM relationship during the impulsive phase of the flare, when compared with that obtained from our synthesis procedure. Determined T & EM, in this phase, have large uncertainties. Thus, such synthesis employing observations only from EUV waveband poses a limitation in the form of unreliable EM values at high temperature.
- ➢ Moreover, Hannah's T-EM synthesis technique results in higher DEM values at the lower temperature (logT < 6.5 MK) in comparison to that derived from Aschwanden's method.

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