RHESSI observation of extremely long persisting HXR sources – SphinX wanted immediately

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Long duration event (LDE)

Soft X-ray
- decay phase lasts several hours
- well observed loop-top sources with sizes 1.0-1.5x10^4 km
- continuous energy release – energy balance, chromospheric evaporation

Hard X-ray
- observed up to 40 minutes after the maximum (light curves) – HXT L channel
- large (1 arc min) and expanding source visible near the loop-top SXR source
- unclear nature – thermal or non-thermal
- regardless of the nature, the existence of the HXR source long after the maximum demands the energy release process

Kołomański 2006
Better spatial resolution – more detailed investigation of sources

Better sensitivity - weak, coronal sources could be detected long after the maximum of the flare

Better energy resolution – more detailed analysis of LDEs spectra
Difficulties

Main difficulties:
- pile-up
- attenuators
- orbital background

~ 160 LDE flares found with the use of GOES lightcurves

~ 50 which last longer than 3 hours in RHESSI observations (6-12 keV)

The example:

July 30th, 2005
X1.3
>10 h
Several hours after the flare maximum the HXR signal is very weak:

- 2-minute intervals
- attenuators out
- outside the radiation belts
- far from the SAA

Thus, for 10 hours decay we have only few time intervals for imaging and spectroscopy
Method

Images:

Time interval: 11:38 – 11:40
Grids: 3,4,5,6,8,9
Pixel size: 1”
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Because of the actual size of the source? – let’s look at the single-detector images
The size of sources changes when the diameter of the source is larger than the FWHM of given grid then the modulation vanishes and the source is no longer observed with this grid. For this reason we have to choose grids in more flexible way.
Method

As the result we obtain well resolved sources.

Time interval: 11:38 – 11:40
Grids #: 8,9
Algorithm: PIXON
Energy ranges [keV]: 5-6, 7-8, 9-10, 11-12, 12-14, 15-23

FWHM of the grid #7 is about 60 arc sec
Comparison with TRACE 171 Å

RHESSI images reconstructed with the use of PIXON method

6-7 keV

All sources (for a given time, different energy) are located in the same region

What is the nature of this source?
30 July 2005 - spectra

Even with the capabilities of RHESSI we are not able to determine the nature of the emission above 10 keV
Typical size of the long persisting HXR source is of the order of $10^4$ km

It rised with the speed less than 1 km s$^{-1}$

To balance the thermal and conductive losses we need a heating rate of the order of 0.1 erg s$^{-1}$cm$^{-3}$ ($10^{27}$ erg s$^{-1}$ from the whole volume)

The energy release lasting for 6-10 hours is a great challenge for existing flare models
Shibata 1995

The main driver of the whole process is the eruption of the filament

The several hours long energy release cannot be explained with this scenario.

Sweet, P. A. 1958

Emergence of the new flux is the main driver in this model.

This idea was recently resurrected by Uchida et al. (1999) and Hirose et al. (2001)

Jakimiec, J., et al. 1998

The existence of the turbulent (highly tangled) magnetic field in the loop-top source could keep up the energy release for long time due to small reconnections inside the structure.

It explains the spatial correlation between the thermal and non-thermal/hot sources observed in the late phase of LDEs
SphinX – the next step

Spectral range: 0.5-15 keV (20-0.8 Å) in 256 channels
Spectral resolution: 250-290 eV
Time resolution: nominal 1 sec for quiet Sun conditions, down to 0.01s in flares.
Photon arrival time measured to 1 μs accuracy (in Time Stamping Mode)

Detectors (four units):
Amptek, Peltier cooled Si PIN diodes.
Detectors’ support plate thermally connected to external heat radiator via heat sink pipe.
SphinX – the next step

- The energy range – exactly what we need
- Energy resolution – about 3 times better
- Time resolution – possible investigation of elementary energy release episodes during the decay phase
- Well resolved details in this range – more precise analysis of the nature of LDE sources
LDEs are well observed by RHESSI. The analysis is complicated due to attenuators, radiation belts, SAA, but not impossible.

HXR sources (above 10 keV) are visible even 6 hours after the maximum of the flare.

Long-lasting HXR sources are located above structures observed in the EUV range. Observed sources are large and grow with time.

The spectral analysis of the sources suggests that at least two components are observed. One is the hot (about 10 MK) and the second is a very hot (20 MK) or steep non-thermal component – SphinX will give an answer.

The observed features imply the existence of the energy release process which lasts several hours – the challenge for flare models.