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Common observations of solar X-rays from SPHINX/CORONAS-Photon and XRS/MESSENGER

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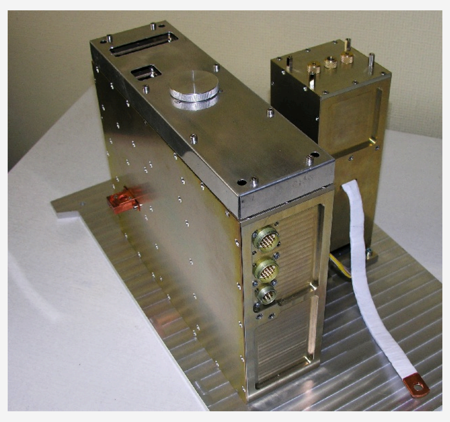
ABSTRACT

SphinX was a soft X-ray spectrophotometer constructed in the Space Research Centre of Polish Academy of Sciences. The instrument was launched on 30 January 2009 aboard *CORONAS- Photon* satellite as a part of TESIS instrument package. SphinX measured total solar X-ray flux in the energy range from 1 to 15 keV during the period of very low solar activity from 20 February to 29 November 2009. During this period the solar detector (X-ray Spectrometer - XRS) onboard *MESSENGER* also observed the solar X-rays from a different vantage point. XRS measured the radiation in similar to SphinX energy range. We present results of the comparison of observations from both instruments and show the preliminary results of physical analysis of spectra for selected flares.

SphinX

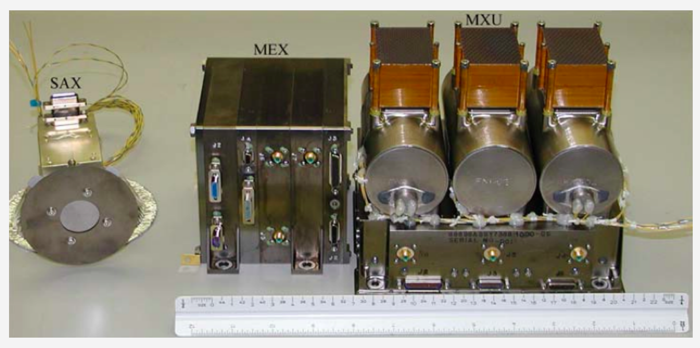


Figue 1: SphinX instrument

- SphinX was the Polish X-ray spectrophotometer on the Russian *CORONAS–Photon* satellite. This instrument was located inside telescope complex TESIS designed at the Lebedev Physical Institute of the Russian Academy of Sciences.
- *CORONAS–Photon* was launched on 30 January 2009 from the Plesetsk Cosmodrome in northern Russia.
- The spacecraft orbit was circular with **an inclination angle of 82.5°**, initial height ~550 km, and **period of 95 minutes**. After the stabilization an **accuracy** of the spacecraft orientation with respect to the Sun was better than **three arcminutes.**
- SphinX instrument used four silicon PIN detectors (D1, D2, D3, D4) equipped with thin 12.7 micron thick Be entrance filters. Detectors D1, D2, D3 were designed for solar X-ray spectroscopic and photometric observations. The fourth SphinX detector D4 was used for fluorescence measurements.
- This Polish X-ray spectrophotometer measured soft X-ray emission from **entire solar disc from February to November 2009 in the energy range between 1.2 and 15 keV.**

XRS Spectrometer

The X-Ray Spectrometer (XRS) on the *MESSENGER* spacecraft measures elemental abundances on the surface of Mercury by detecting fluorescent X-ray emissions induced on the planet's surface by the incident solar X-ray flux. Because the Sun is the primary source of the planetary X-ray fluorescence, the knowledge of highly variable flux is required for accurate modeling. To this aim the part of XRS is a small aperture (0.03 mm^2) Si-PIN detector used as a solar monitor.



Figue 2: XRS spectrometer

- XRS instrument consists of three gas proportional counters view the planet, and a state-of-the-art Si-PIN detector mounted on the spacecraft sunshade views the Sun.
- Si-PIN detector has a 0.03 mm^2 aperture that views through 75μm-thick beryllium to limit and harder solar X-ray contribution to this detector.
- XRS measured soft X-ray emission from **entire solar disc in energy range between 1 and 10 keV from February to November 2009.**

COMMON OBSERVATIONS

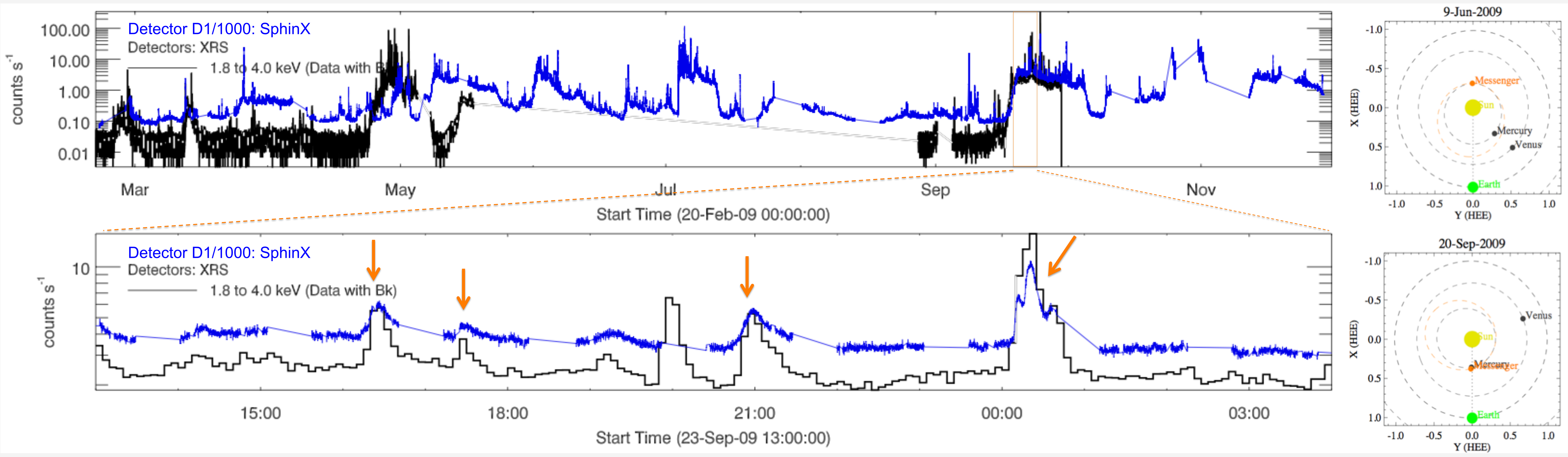


Figure: 3 Left: XRS (black) and SphinX (blue) irradiance variation in the 1.8—4 keV band for the time interval February – November 2009 (top) and for 23 and 24 September 2009 (bottom). Difference in shapes are related to different parts of the Sun observed by both instruments. In September 2009 MESSENGER orbit was very similar to SphinX and both instruments observed the same part of the Sun. During 2009 the XRS was twice turned off: from 17 May 2009 to 28 August 2009 and from 1 October 2009. The arrows above the plot point to the flares selected for analysis. *Right: Positions of the MESSENGERr (orange) relative to the Sun (yellow) and Earth (green) for 9 June 2009 (top) and for 20 Sep 2009 (bottom). The dotted lines show the angular displacement from the Sun. Units are in A.U. The positions were calculated using SPICE package available in SolarSoft.*

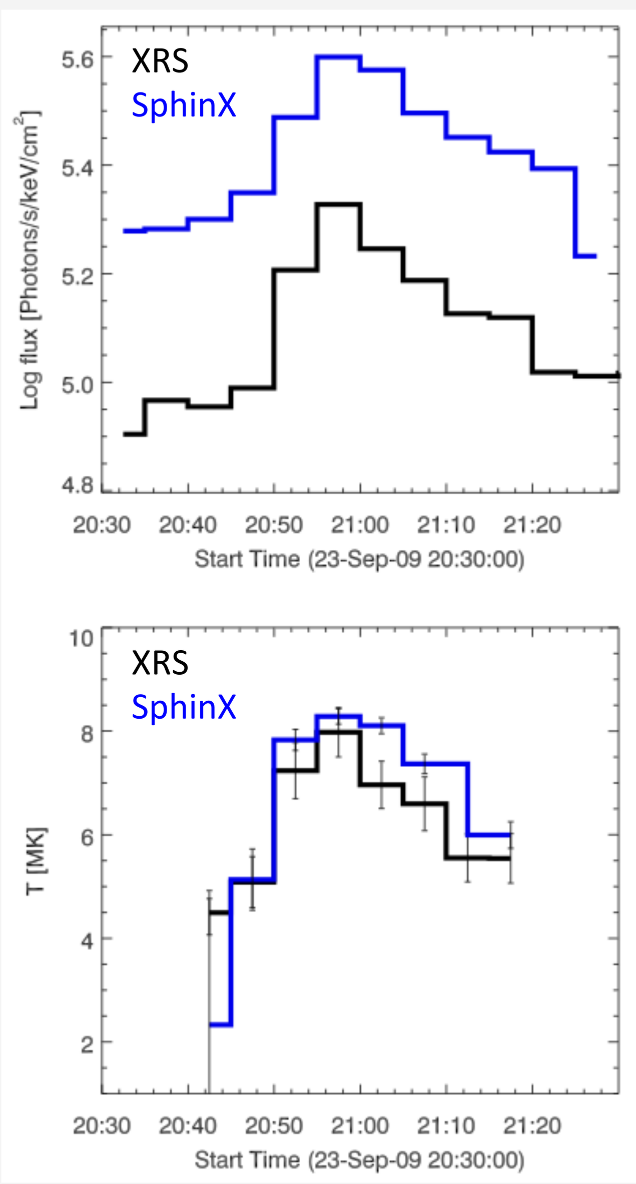


Figure 4. XRS (black) and SphinX (blue) lightcurves (top panel) and temperature (bottom panel) for 23 Sep 2009 ~20:58 UT flare (energy range from 1.8 to 4 keV). The photon spectra were obtained using diagonal part of detector response matrix (DRM). Temperature was calculated using Object Spectral Executive package available in SolarSoft (Variable Thermal vth function, background was subtracted).

LIST OF ANALYZED FLARES

No	Date	Peak time	GOES class
1	23 Sep 2009	16:25 UT	A4
2	23 Sep 2009	17:28 UT	A2
3	23 Sep 2009	20:58 UT	A4
4	24 Sep2009	00:20 UT	B1

We have analyzed four flares simultaneously observed with SphinX and XRS. The selected events occurred on 23 and 24 September 2009 (when SphinX and XRS/*MESSENGER* observed similar parts of the solar disc – see Figure 3). XRS/*MESSENGER* observations were corrected for times and area to Earth view.

The photon spectra were obtained using diagonal part of detector response matrix (DRM). The temperatures (only for two "stronger" flares: nr 3 and 4) were calculated using Object Spectral Executive package (ospex) with the following circumstances: one isothermal component assumed, background subtracted, reduced chi-squared for the best fit, no pileup correction made.

CONCLUDING REMARKS

1. During the SphinX operation (February - November 2009) observations from X-ray Spectrometer aboard *MESSENGER* are available. This period corresponds to a deep minimum of solar activity (between Cycles 23 and 24). The range of performed comparison was limited to the spectral range below 4 keV as the flares available for analysis were of class A and B.
2. We compared temperatures from SphinX and XRS spectra using ospex package available in SolarSoft. For two analysed flares SphinX and XRS temperature values are similar (within the limits of uncertainty). However the temperature values strongly depend on assumed background level (weak events).
3. The analysis based on the larger sample of commonly observed events is planned in future.
4. For selected flares we observed that SphinX values of flux are systematically ~2 times higher than XRS fluxes independent of the phase of the flare evolution. This indicates for a possible problem with the absolute calibration of the instruments.

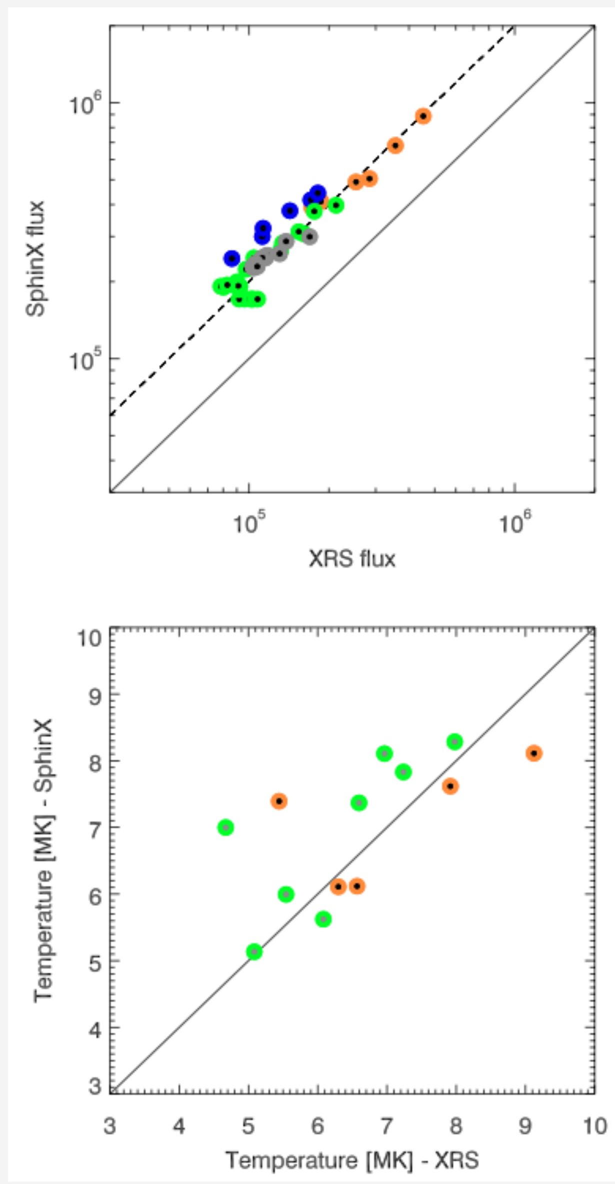


Figure 5. Top: The correlation plots of XRS and SphinX fluxes for analyzed flares obtained for energy band 1.8 keV – 4 keV. The different colors correspond to individual events (see the Table). For fluxes the points from observations are located around the line corresponding to SphinX values two times higher than XRS ones (solid line represents line of equal values) Bottom: The comparison of temperatures determined using XRS and SphinX data for flares nr 3 and 4 (see the Table).

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