RESULTS OF XUV FULL SUN IMAGING SPECTROSCOPY FOR ERUPTIVE AND TRANSIENT EVENTS BY THE SPIRIT SPECTROHELIOGRAPH ON THE CORONAS-F MISSION

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ABSTRACT

SPIRIT (SPectroheliographIc soft X-Ray Imaging Telescope) is the current experiment on board the CORONAS-F satellite launched on July 31, 2001 (Oraevskii & Sobelman, 2002). The main goal of this experiment is to study a structure and dynamics of the solar atmosphere in the wide scale of heights (from the chromosphere to a far corona) and of temperatures (from ten thousands through thirty millions Kelvins) by means of the XUV imaging spectroscopy. Since the launch of the CORONAS-F satellite more than three hundred thousands of images and spectroheliograms have been recorded. For the first time continuous series of monochromatic full Sun images in MgXII lines at 8.42 Å (doublet: 8.418 and 8.423 Å) were obtained. These series include long-term continuous observations of duration up to 10 days with the cadence of 100 sec as well as temporal sequences with duration of a few minutes and high resolution of 7 sec, synchronized with flares. The spectroheliograms for the whole disk and off-limb regions are also recorded in the spectral bands 177 – 207 and 285 – 335 Å providing spectra with high resolution of various coronal structures including eruptive and transient events. This paper presents preliminary results of quick-look analysis of some observational data obtained by means of the SPIRIT spectroheliographs.

THE SPIRIT EXPERIMENT

Experimental

The instrumentation complex SPIRIT consists of telescopes/spectroheliographs including 10 spectral channels in the range 8.42 – 335 Å. This complex provides full Sun images in spectral lines as well as in narrow spectral bands with high temporal, spatial and spectral resolution. The monochromatization and focusing of the emission are obtained by means of multi-layer coated and Bragg crystal mirrors, and grazing incident holographic gratings. The detectors are constructed on the base of image intensifiers with open micro-channel plate, Charge Couple Devices (CCD) sensitive to the X-ray and visible emission and spectral filters: thin aluminum and Mylar (PET) films and microporous membranes. The instrumentation control is implemented by two main digital signal processors (DSP) functioning in the regime of remote computers. It allows to control each of the 10 SPIRIT channels (8 parameters) with the help of the daily cyclograms without re-programming of the main processors. In the case of necessity complete re-programming is carried out from the Earth by the upload channel. For the SPIRIT instrumentation the telemetry system provides downloading and uploading the information, respectively, 120 MB and 20 KB per day. More detailed description of the SPIRIT instrumentation is given in Zhitnik et al, 2002a.

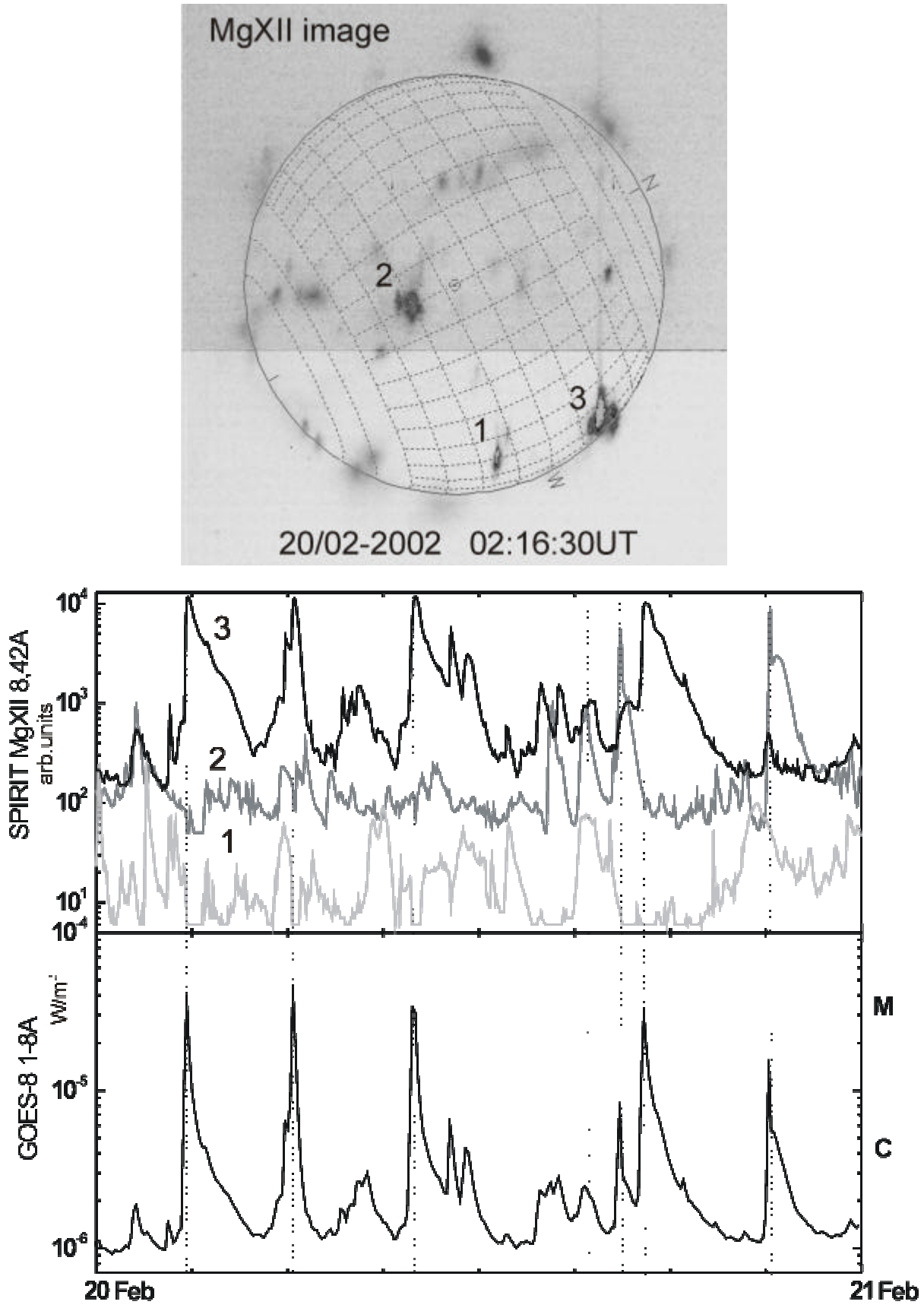

Fig.1. Temporal dependence of the total flux in three different regions on the solar disk for the period of 24 hours detected on February 20, 2002 in the monochromatic MgXII images; the data from GOES for that period are also given.

Monochromatic full Sun images in the MgXII line at 8.42 Å

Images in the monochromatic MgXII line emission at 8.42 Å in distinction to that in spectral bands give a direct and "pure" information on hot plasma structures with temperatures in vicinity of 10 MK (see Bonnelle et al. 1973, Zhitnik et al., 2003). The main morphological and dynamical features of such structures have been already described in the paper of Zhitnik et al., 2003. However only long-term continuous observations of the sun by the MgXII images with high temporal resolution made it possible to discover new impressive forms of "alived" activity of the solar corona specific for this temperature level. The series of images presented on the movie during the report revealed an extremely wide spectrum of dynamical phenomena in the both local and global scales of the solar atmosphere. Remarkable features of these phenomena are high variability in brightness and substantially different dynamical behavior characterized by life-times from minutes up to days.

The following new dynamical phenomena were observed:

- Diffuse hot plasma clouds at high altitudes up to 0.3 solar radius grown to the size of about 0.4 solar radius, sometimes developing to well distinguished "spider"-like forms with the life-time of a few hours and decaying through series of expanding arches;
- Flare associated plasma motions of different kinds appearing as the propagation of hot plasma fronts and/or as the sequential ignition of arches;
- Giant arches revealed to a size up to 0.4 solar radius;
- "Pulsing" flares;
- High variability of a number of micro-bursts on the solar disk;

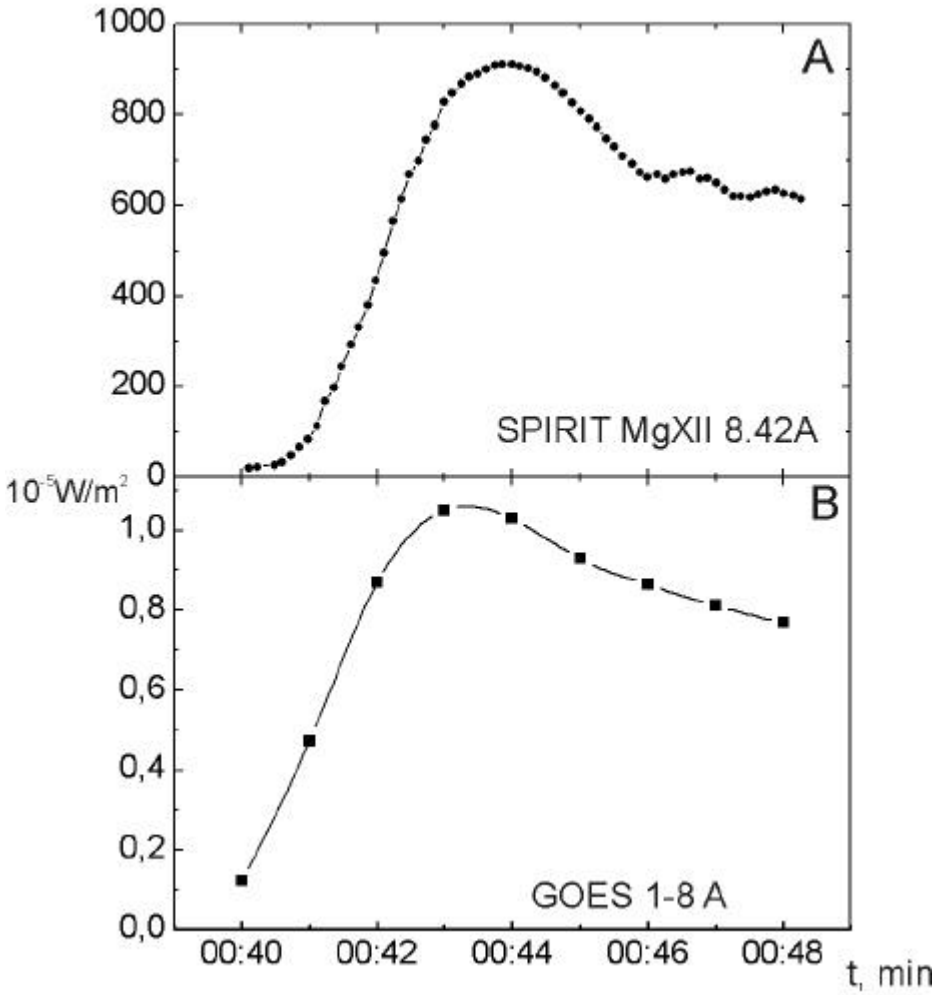

Fig.2. The intensity of the brightest 8x8 arc sec area of the M-class solar flare on October 4, 2002 (initial and maximum phases), observed in monochromatic MgXII line at 8.42 Å with time resolution of 7 seconds.

Characteristic property of the compact plasma structures seen in the images is that they are associated but not coincide with some active region systems and are characterized by specific shape and dynamics, different to that of the relatively low (1 - 2 MK) temperature active region plasma. An example of a "spider"-like structure is given in Zhitnik et al. (2003), where an exclusive character of a spatial distribution for the relatively cold and 10 MK plasma is demonstrated.

Figure 1 presents the temporal dependence of the total flux in three different regions on the solar disk for the period of 24 hours detected on 20 February 2002.

The example for the evolution of a flare recorded with 7 sec cadence is given in Figure 2.

Spectra of coronal structures

Monochromatic images of the entire solar disk and regions above the limb have been taken in the emission lines

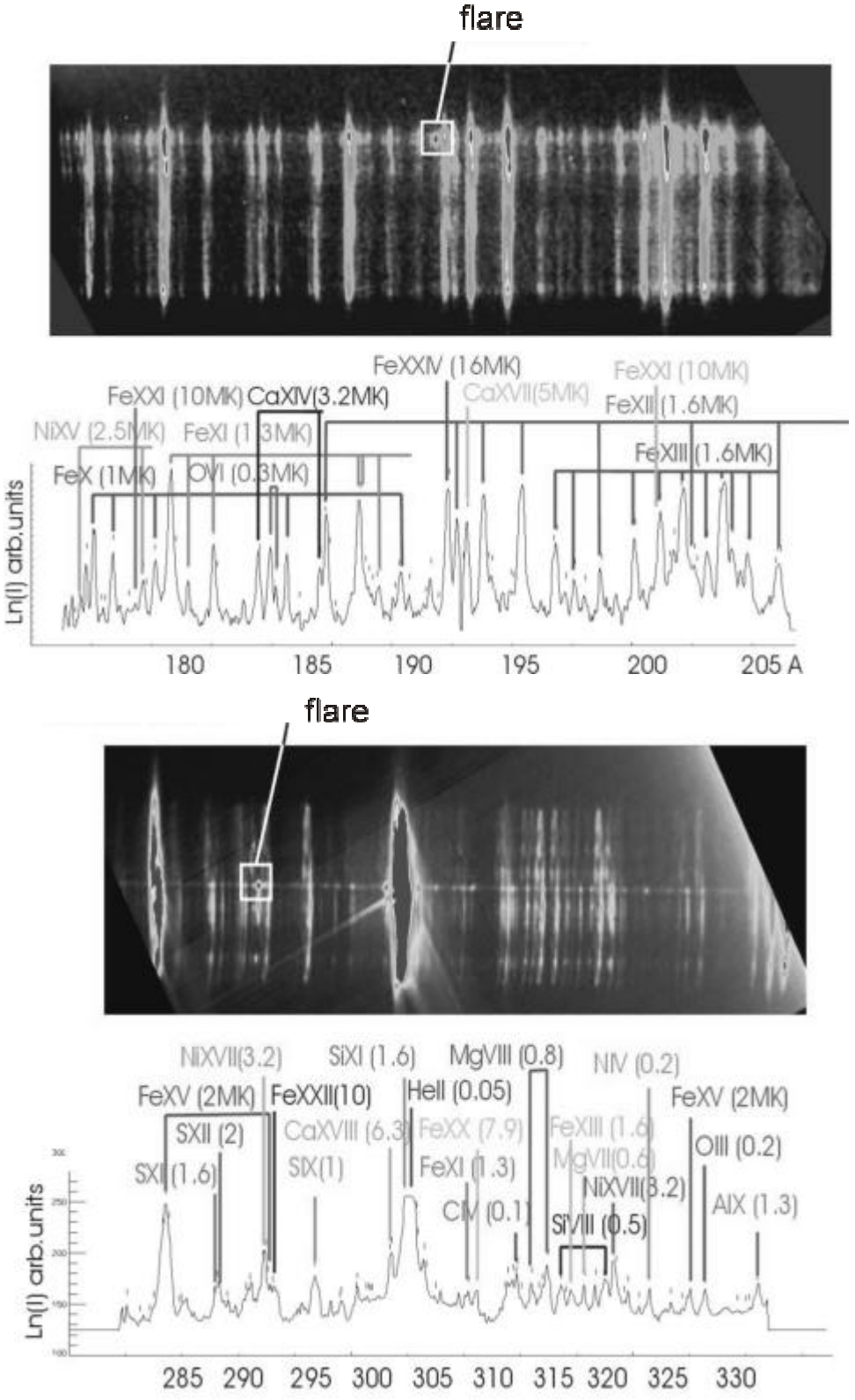

Fig.3. The spectroheliograms and emission-line spectra of the M-class flare recorded on September, 25 2002, 04:50UT in the spectral regions 177-207 Å and 285-335 Å (adapted from Zhitnik et al., 2002b).

of the two wavelength ranges 177-207 Å and 285-335 Å simultaneously for the first time. The spectroheliograms obtained with the high spatial resolution of 8×160 arc sec clearly revealed temporal and long-lived coronal plasma structures: active and quiet Sun regions, coronal holes, flares etc. The emission-line spectra of the M-class flare recorded on September 25, 2002, 04:50UT with the resolution 25 and 40 mÅ are presented in Figure 3. Preliminary analysis of these spectra revealed 150 spectral lines for about 75 lines in each spectral band.

The spectra include iron lines due to transitions in ions of various ionization stages in a wide range from FeIX up to FeXXIV being important for the DEM modeling of the coronal plasma for the temperature region from 1 through 16 MK.

The lines emitted by the ions of other elements (He,C,O,Mg,Al,Si,S,Ca,Ni,) corresponding to the temperatures in the range 0.05 – 6 MK provide a complimentary information for the DEM modeling as well as for the relative element abundance determination.

CONCLUSION

The new approach based on the ***monochromatic*** full Sun imaging spectroscopy (MFSIS) is realized in the current experiment SPIRIT on board the CORONAS-F satellite. Preliminary results of quick-look analysis of some observational data obtained by the SPIRIT spectroheliographs allows to conclude:

i). This approach happens to be fairly important to study dynamical phenomena of solar activity specific for the temperature level of about 10 MK;

ii). The experiment SPIRIT provides new channel of complementary information necessary to link the results of observations of low (1-3 MK) and high (≥20 MK) temperature plasma in the solar atmosphere caring out in the current experiments on the SOHO, TRACE and RHESSI missions.

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