MULTI-WAVELENGTH HIGH RESOLUTION OBSERVATIONS OF A M5.4 FLARE FROM GROUND AND SPACE

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ABSTRACT

We present observations of all phases of a M5.4 flare and the associated CME which occurred in active region AR 10646 (N12, W43) on July 13, 2004. Multi-wavelength observations were performed in a coordinated campaign to cover the whole solar atmosphere from the photosphere to the corona. Observations were made with the German VTT, (WL, H-alpha images, photospheric spectral lines near the flare), SOHO/CDS (six spectral lines), SOHO/EIT, and TRACE. Supplementary data were collected from astronomical databases, namely SOHO/MDI (white light and magnetograms), SOHO/LASCO, RHESSI X-ray data, full Stokes magnetograms from Mitaka, Big Bear and Haleakala observatories, GOES X-ray data and radio-observations from Trieste, Zürich, IZMIRAN-Irkutsk and Potsdam. The temporal evolution of the event is presented in particular channels and spectra and some results are discussed. Especially the dynamics of a filament eruption was observed in both H-alpha and TRACE (19.5 nm). In addition intensity and velocity oscillations observed in SOHO/CDS spectra and the coupling and timing of different hot layers revealed in RHESSI, SOHO/CDS, SOHO/EIT and TRACE data with the CME observed with SOHO/LASCO are documented.

Key words: Sun: flare and CME evolution; Sun: magnetic field; Sun: atmosphere.

1. INTRODUCTION

The occurence of a particular solar flare associated with CME (Coronal mass ejection) still remains an unpredictable process and coordinated multi-wavelength observations with high spatial and temporal resolution are rarely reported. We observed such a process on July 13, 2004 in active region AR 10646 (N12, W43) as a flare M5.4. The observations were performed in a frame of coordinated observing campaign and supplementary data for this event were found in astrophysical databases and in institutional archives.

2. OBSERVATIONS

The coordinated observations were performed with the following instruments:
1) German Vacuum Tower Telescope at Observatorio del Teide, Tenerife, (H-alpha and white-light images)
2) SOHO/CDS (spectra in six spectral lines)
3) SOHO/EIT (images)
4) TRACE (images in continua and spectral lines)
Supplementary data were collected from:
5) SOHO/MDI (intensities, magnetic field)
6) RHESSI (X-rays)
7) Mitaka, Big Bear, Haleakala (full Stokes magnetograms)
8) GOES instrument (X-ray)
9) Trieste, Zurich, IZMIRAN Irkutsk, Potsdam (radio observations)
10) SOHO/LASCO, C2,C3 (intensities)

The temporal coverage of different phases of the flare with various instruments is given in Fig. 1. It is seen from the Fig. 1 that the impulsive phase of the flare was observed with all mentioned instruments.

The highest temporal resolution was achieved in H-alpha observations with the VTT. The observations were performed from 08:31:13 - 09:13:05 and total number of 643 CCD online images 768x756 (FITS, 8 bits) with temporal resolution 5 seconds were stored. In addition a S-VHS video was recorded from 08:27:40 until 10:01:23 and more than 100000 images (768 x 756 pixels) were grabbed with temporal resolution 1/24 second.

SOHO/CDS Observations were performed with the NIS detector using ”sit and stare mode” i.e. the slit position was fixed and the solar rotation was not compensated. The width of the slit was 4 arcseconds and the length was 141 arcseconds. A set of 6 EUV spectra was recorded simultaneously. The exposure time of the particular spectrum was 10 seconds and the set of the six spectra was recorded every 15 seconds. Used lines are: He I 58.433

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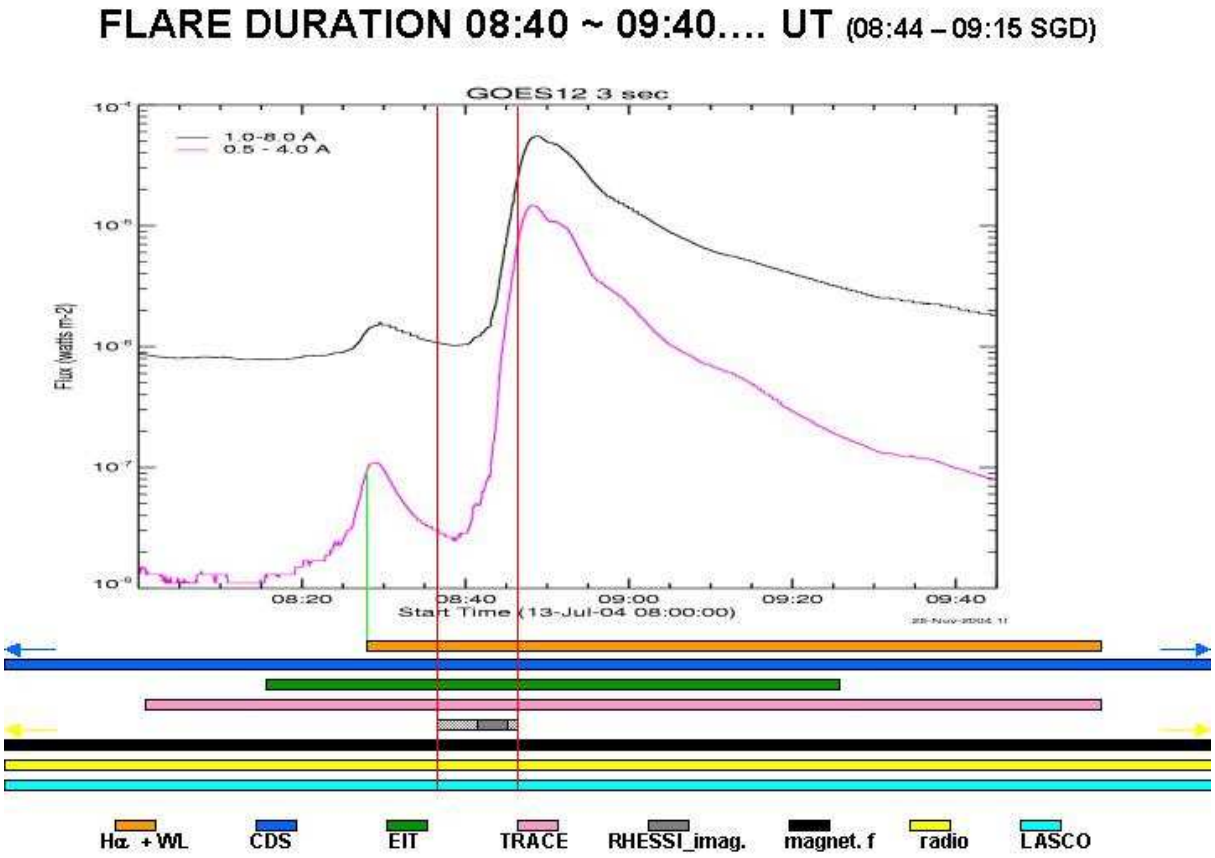

Figure 1. The temporal coverage of different phases of the flare with various instruments. The first left vertical line marks the start of H-alpha observations and next two vertical lines mark the phase of the flare covered by all instruments. The horizontal bars from top to bottom mark the duration of observations with the following instruments: VTT, CDS, EIT, TRACE, RHESSI, MDI, radio observations, LASCO. On top the X-ray flux from GOES is shown.

nm (2×10^4 K), O III 55.959 nm (8×10^4 K), O V 62.973 nm (2.5×10^5 K), Ne VI 56.280 nm (4×10^5 K), Mg IX 36.804 nm (1×10^6 K) and Si XII 52.067 nm (2×10^6 K). From SOHO/EIT we have observations in line Fe XII 19.5 nm which mapped temperature 1.6×10^6 K. The observations are from 08:15 - 09:26 with temporal resolution 12 minutes. Examples of H-alpha, CDS and EIT observations are shown in Figs. 2 and 3.

SOHO/MDI magnetograms are available every minute. For modeling of the magnetic topology we will use magnetograms in hourly intervals. Each value is computed as an average of last five images in every hour starting from 00:00 UT on July, 10 until 24:00 UT on July 13. In addition full Stokes magnetograms from Mitaka, Big Bear and Haleakala are available of the particular flare.

The observations in X-ray were performed with GOES and RHESSI satellites. In Fig. 7 we document the observations and temporal coverage in different energy bands of the RHESSI instrument.

TRACE observations covered three continua, two spectral lines and white-light channel. Namely the observa-

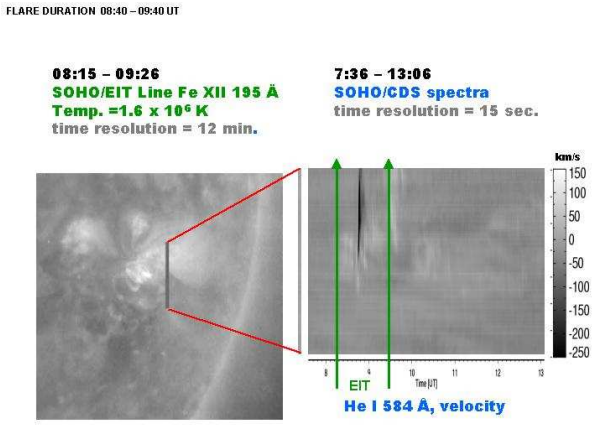

Figure 2. EIT observations and CDS time-space slice of velocities in He I 58.4 nm line. The two vertical lines in the CDS map show the coverage of EIT observations. Note changes of velocities during and after the impulsive phase of the flare.

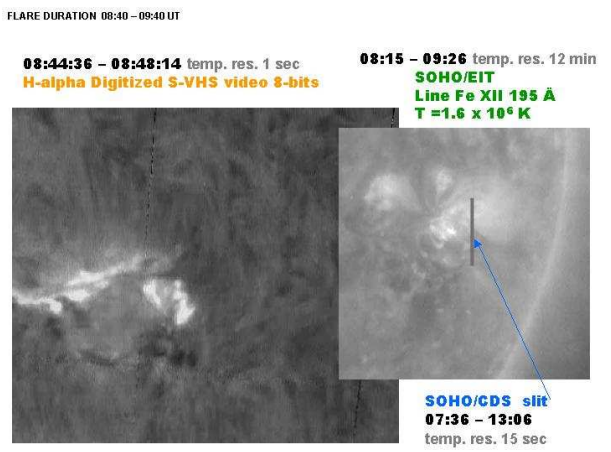

Figure 3. Snapshots of H-alpha and EIT observations with marked position of the CDS slit.

tions were performed with the following characteristics:
155.0 nm cont., 08:00 - 09:00 UT, temp. resol. 3-7 min.
160.0 nm cont., 08:00 - 09:59 UT, temp. resol. 3-7 min.
170.0 nm cont., 08:40 - 09:59 UT, temp. resol. 3-7 min.
17.1 nm, line, 08:00 - 09:59 UT, temp. resol. 40 sec.
19.5 nm, line, 08:43 - 09:03 UT, temp. resol. 5 - 25 sec
white-light, 08:00 - 09:53 UT, temp. resol. 3 -7 min.
After careful comparison of the H-alpha and trace movies, we found, that in both H-alpha and TRACE 19.5 nm line images dark filamentary structures are present over the bright flare kernels. One example of TRACE observations in 160 nm continuum is shown in Fig. 5

Radio observations were collected from databases of the Institute of Solar-Terrestrial Physics, Siberian Division, Russian Academy of Science; The Institute of Astronomy, ETH Zurich; AIP, Potsdam; and SOLRA - SOLar Radio Archive, Trieste. In Fig. 6 dynamical spectra from Zurrich and Potsdam are shown.

The flare was associated also with a CME which was clearly observed with LASCO C2 and C3 coronagraphs. In Fig. 4, the difference image of the CME in C2 is given together with appropriate phase of the flare documented by GOES X-ray flux.

3. CONCLUSIONS

The data obtained shall be used for the investigation of the dynamics of the solar atmosphere associated with the flare. In particular it is intended to use them for:

1) modeling of the CME-flare system evolution and associated shock.
2) modeling of the flare energy release and energy and mass propagation through the upper solar atmosphere in the particular flare.
3) evaluation of the three dimensional MHD model of the active region evolution - comparison of photospheric

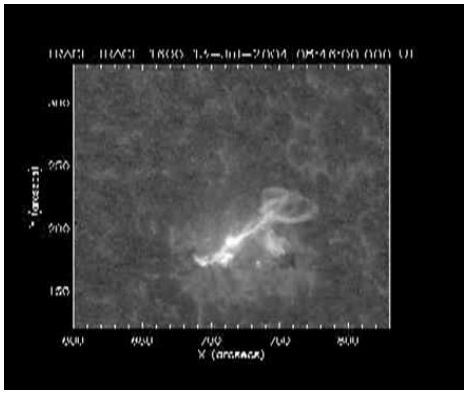

Figure 5. An example of TRACE observations in the 160.0 nm channel at 08:46 UT.

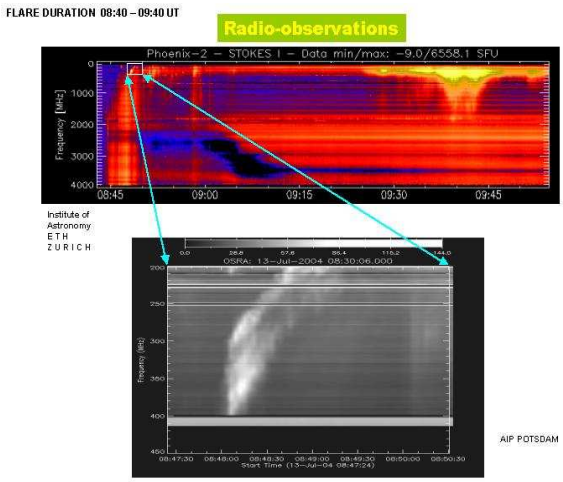

Figure 6. Dynamic radio-spectra from Zürich and Potsdam for the event coupled with the M5.4 flare

shears and magnetic topology generated by the model to the observed quantities.
Cooperation with CSPAR/UAH, Center for Space Plasma and Aeronomic Research, University of Alabama, USA, and University of Zagreb, Croatia, have started.

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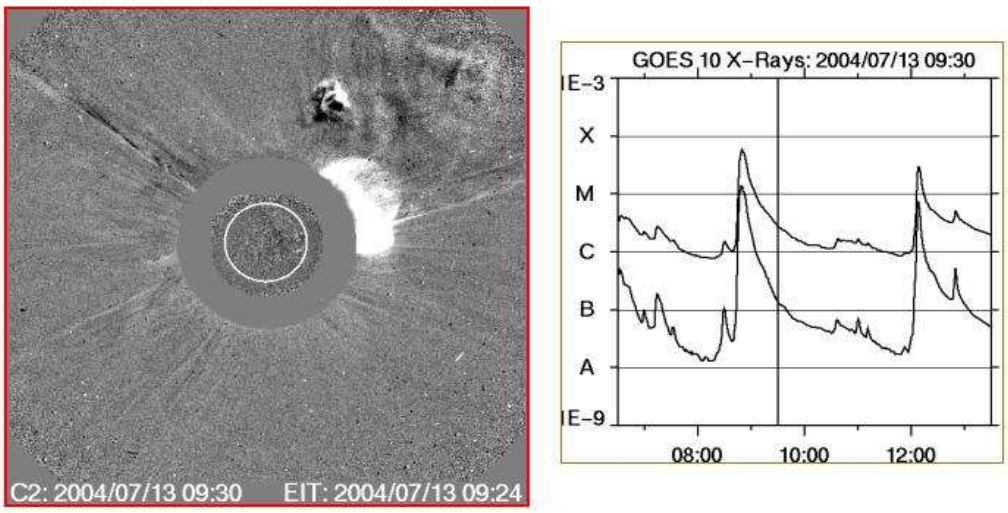

Figure 4. Difference image of the CME in C2 taken from CME catalog given together with appropriate phase of the flare documented by the GOES X-ray flux.

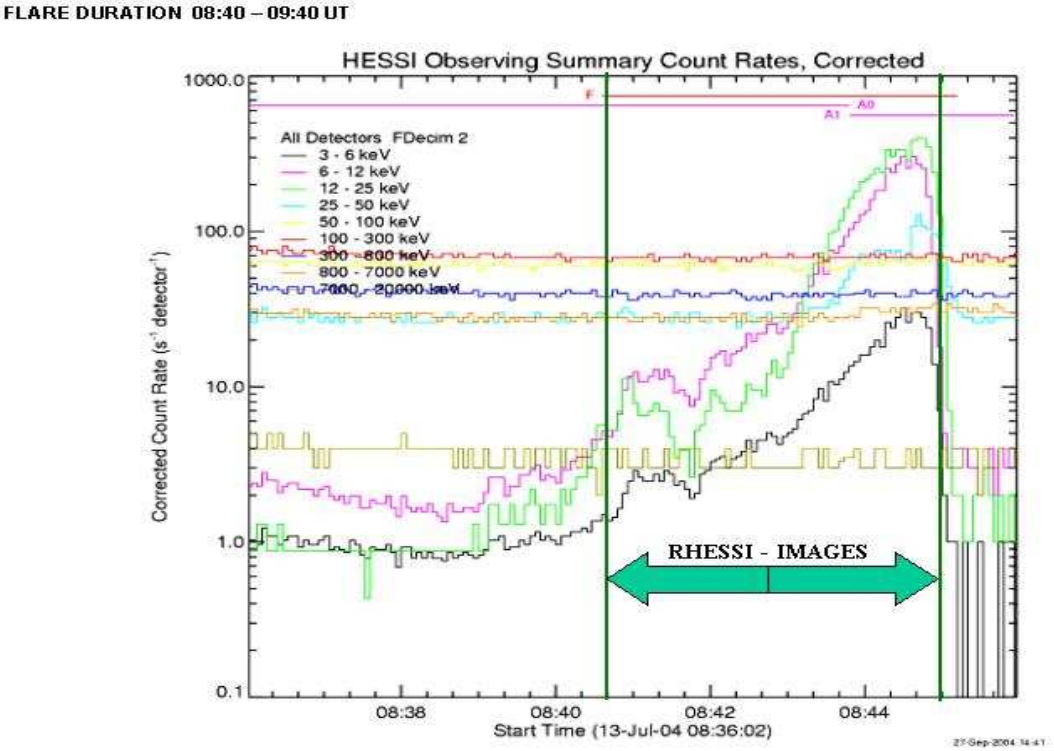

Figure 7. RHESSI X-ray light curves in different energy bands. The thick arrows mark the time, in which images in 6–12 keV and 25–50 keV band were reconstructed.