Proposal for Hinode/EIS+SOT+XRT Joint Observing Campaign:

Physical mechanisms driving solar microflares and supergranular network dynamics - relevance for coronal heating

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May 31, 2007

1 Science objectives

This proposal merges together attempts to observe two kinds of solar structures – solar microflares and supergranular network – which are planned to be investigated to address common open questions on their relevance for the **heating and dynamics of the solar corona**.

Microflares are small-scale dynamic events potentially important for the heating of the solar corona as well as for the mass supply to the corona and the solar wind. Intrinsically, due to their small sizes and fast dynamics, the analysis of microflares demands high spatial resolution observations combined with good temporal cadence. Our objective is to analyse the dynamics and plasma evolution during microflares by studying the chromospheric response to electron beam and/or conductive heating together with the transition region and coronal response in imaging data combined with X-ray spectral analysis. These observations will allow us to draw inferences on the plasma temperature and emission measure evolution as well as on the importance and energetics of accelerated electrons in microflares. In addition, we plan to use EUV spectroscopy to study mass motions related to the chromospheric evaporation process. The comparison of these observational data with theoretical predictions in the frame of electron-beam-driven and conductively driven chromospheric evaporation for individual microflares can help us to better understand: a) whether non-thermal electrons are present in microflares which hints at magnetic reconnection as the underlying physical process, b) how much plasma is brought into the corona by microflares, c) which process (electron beams or heat conduction from the hot coronal microflare plasma) dominates the mass transport, d) how much energy available for the heating of the corona is deposited during microflares.

Supergranular network is clearly related to the heating of the corona as well. On the other hand its close relation to the underlying layers is obvious today. Photospheric and chromospheric layers are planned to be investigated in order to identify the most probable physical mechanisms responsible for the energy transfer and dynamics of the solar corona above the chromospheric network. Our previous results derived from data of the SOHO JOP 78 indicate presence of downward propagating waves in/above the chromospheric network. These results led to the assumption that reconnection of the magnetic field lines should be the dominant mechanism to heat the solar corona above the particular chromospheric network. In contrast, findings of other authors show evidence of propagating intensity oscillations spreading out from the photosphere to the corona and therefore prefer alternative heating mechanism of the corona, i.e. dissipation of magneto-hydrodynamic waves which originate from the solar convective zone. To clarify these findings simultaneous measurements of Hinode/EIS,SOT,XRT and the TRACE satellite are proposed supporting the DOT Hα imaging. As the drivers of all proposed heating mechanisms are localized in the photosphere we expect that time series of the speckle-reconstructed DOT filtergrams taken simultaneously with the EIS spectra and the supporting Hinode/SOT,XRT photospheric and coronal data will provide an excellent material to study the properties of the mentioned drivers.

2 Planned analysis

Below the basic approaches and tools we have in mind to apply to the acquired data are briefly introduced:

Microflares: we plan to use the high-resolution images acquired by the DOT in the Hα and Ca II H spectral lines in a high time cadence mode in order to study the chromospheric signature of microflares in terms of geometry/topology, source sizes, and evolution. These data shall be combined with observations from Hinode/EIS+SOT+XRT, RHESSI, TRACE and KSO. RHESSI and KSO data will be available in the desired mode. High resolution longitudinal photospheric magnetograms from the Hinode/SOT instrument merged with the chromospheric and coronal microflare emission (SOT, DOT, RHESSI, TRACE, XRT) will allow us to get insight into the magnetic topology and connectivity of the microflares. Hinode/EIS spectroscopy will be applied in order to study mass motions and emission related to chromospheric evaporation in microflares. Hinode XRT images will be used to study microflare loops in terms of connectivity and source sizes and plasma diagnostics, combined with RHESSI. The delay between the impulsive phase and the appearance of (post-)flare loops in the XRT and TRACE channels together with the flare peak temperatures inferred from RHESSI spectroscopy also allows us to get insight into the cooling of the flare plasma. The RHESSI instrument will be used to study evolution of the integrated full-Sun soft and hard X-ray fluxes (thermal-nonthermal behaviour), imaging of the soft X-ray flare loop and, if possible, X-ray spectroscopy in the range 3–20 keV to study the thermal flare plasma (combined with XRT) and the energetics and importance of accelerated electrons.

Supergranular network: the EIS spectroscopy provides good temperature coverage of the line emission from chromosphere up to the corona. Therefore, the EIS data are planned to be used for the study of waves in the upper solar atmosphere and for the determination of direction of the wave propagation. To do that we will apply cross-correlation technique and wavelet analysis on the intensities and the Doppler shifts of the selected EIS spectral lines. Similar analysis was already performed by our group using the SOHO/CDS data. Complementary Hinode/SOT magnetograms will be also used for the study of the evolution of the photospheric magnetic fields together with magnetic elements, visible mainly in the G-band channel as the photospheric bright points concentrated in the network. Such magnetic elements are considered to be the prime candidate for drivers of the coronal heating mechanisms. Moreover, time series of the DOT filtergrams taken especially in the Hα and Ca II H spectral lines will provide additional information about the behaviour of waves in the upper solar photosphere and chromosphere, and they will therefore allow a better identification of the coronal heating mechanism. TRACE measurements will be used mainly for searching for the transition region and coronal responses of the propagating/standing waves.

3 Campaign Outline

3.1 Participating Instruments

Ground-based instruments: DOT (LaPalma, Spain), Kanzelhoehe Solar Observatory (Austria), Hvar Solar Observatory (Croatia)
Space-born instruments: Hinode: EIS/SOT/XRT; SOHO: CDS/MDI/EIT; TRACE; RHESSI

3.2 Dates and Times

Granted DOT period: 03 – 31/08/2007
Requested SOHO period: request numbered as the SOHO JOP 189. Realistically the SOHO support can be expected only for the period 3-17/08/2007, 07:00-13:30 UT due to SOHO keyhole starting Aug 18.
Requested HINODE period: preferably 18-31/08/2007, 07:00-13:30 UT as no SOHO support is expected after Aug 17). If possible we are interest also for cooparative SOHO and Hinode observations before Aug 17, if possible.

3.3 Observing Program

3.3.1 Targeting

Two types of target are selected for the proposal: 1/ active regions (microflares); 2/ solar network near disk center (network dynamics). This "two targets approach" was successfully used in July 2006 for support of our previous DOT campaign: an active region is selected when it is located near the disk center and for the rest of days observations of the solar network is scheduled. Decision on the target type and pointing will be specified via e-mail a day in advance according to the actual status of solar activity.

3.3.2 Duration

Aim is to get non-interrupted sequences of measurements for several hours (07:00-13:30 UT) when the best seeing condition can be expected at La Palma (DOT).

3.3.3 Hinode Observations

We are interested in the cooperative observations of all three Hinode instruments. Particularly EIS and SOT are crucial for the proposal.

1. **SOT:** We plan (if possible) to run in time a sequence of 3 exposures: 2 using the BFI imager and 1 using the NBI imager. The reason is to cover evolution of the photosphere with its magnetic concentration signatures (G-band), evolution of the longitudinal component of the magnetic field vector in the photosphere, and evolution of chromosphere (Ca II H) with a reasonable temporal resolution (∼10 s per image, ∼30 s per sequence of 3 selected channels).

   - BFI: G-band and Ca II H channels, FOV: 109"x109" (1kx1k mode, binning 2x2 pxs), 3bit JPEG compression, cadence: ∼10 s per filtergram, telemetry needed: 300kbps, no compensation of the solar rotation
   - NFI: FeI 630.25nm longitudinal magnetograms, other parameters as in case of BFI
   - SP: none

2. **EIS:** measurements are proposed using 2 prepared rasters acronymed as 'Context_calib_jr' and 'Obs_sit_stare_jr'. They have been specified using the EIS study template and the corresponding .DEF file which were already sent to the EIS SSC L. Culhane. The EIS

measurements should start and ends with 3 repetitions of the scanning 'Context_calib_jr' raster (28 minutes). In between the sit-and-stare 'Obs_sit_stare_jr' raster (5.6 hours) is scheduled. Intention is to place the EIS slit for the sit-and-stare raster to the middle of the X-range of the previous scanning raster. For both rasters the same set of 11 selected lines is used.

3. **XRT:** high cadence of the images is required using just one selected filter using no binning and loss-less compression of data.

   - **Microflare mode:** 256x256 px, thin Be filter, exposure max. 1 s with AEC, cadence 10 s
   - **Network mode:** 384x384 px, thin-Al/Mesh, exposure max. 15 s with AEC, cadence 15 s

   For the each particular day target will selected well in advance leading to the corresponding XRT observing mode.

3.3.4 DOT observations

As the main goal we plan to observe with the highest possible time cadence the chromospheric Hα and Ca II H spectral lines – cadence of ∼10 s for speckled images. For further context information on photospheric layers and magnetic flux concentrations (as well as for co-alignment between the various instruments) continuum and G-band images are planned to be acquired.

To increase probability that the ground-based H α observations will be acquired the campaign will be supported also by Kanzelhoehe Solar Observatory (full disk) and Hvar Solar Observatory (limited FOV) high cadence observations.

3.3.5 RHESSI observations

RHESSI observes the Sun in soft and hard X-rays (as well as γ-rays) with a full-Sun field of view. Interruptions of the observations are due to the spacecraft day/night cycle (1 RHESSI orbit ∼ 97 min) and passages over the South Atlantic Anomaly. The maximum spatial resolution is $2.3''$ and the highest time resolution is 2 s depending on count statistics. For microflares the spatial resolution is usually restricted to $7''$ and the time resolution in imaging and spectroscopy to ∼20 s. The temporal resolution for the flux evolution in X-rays may be as good as 2 s also for microflares. Microflare studies with RHESSI require that there is no attenuator in the detectors field of view (A0 state) in order to ensure highest sensitivity at low X-ray energies. The A0 state is the default RHESSI observing mode during times of low solar activity which is expected to be the case during the phase of solar cycle minimum in 2007.

3.3.6 TRACE observations

We are interested to acquire high resolution EUV images (0.5") in the Fe IX 171 Å spectral channel with high temporal cadence (∼30 s). A set of white light, H I Lyman α and UV 1600 Å continuum images shall be acquired as context information as well as for co-alignment purposes each ∼10 minutes. Exposure times in different spectral channels should be controlled by automatic exposure control of the TRACE satellite.

3.3.7 Data Analysis Requirements

Our group has experience managing ground-based and space-born instruments in cooperative campaigns (see e.g. record of our last campaign[1]) and analysing such kind of data (DOT, TRACE,

[1] http://www.astro.sk/~choc/open/06_dot/06_dot.html

RHESSI, SOHO: CDS, MDI, EIT) using our own infrastructure. We expect reduction of the Hinode: EIS, SOT, XRT data will be available using the IDL routines and calibration data distributed within the SolarSoft.

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