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Title of Proposed Observation:

GREGOR-Hinode-IRIS observations to study flares over a wide spectral range

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Main Objective:

The main goal is to investigate effects and energetics of flares on the lower solar atmosphere in detail by combining spectral measurements throughout the UV, visible, and IR. We would like to request co-observations of IRIS and Hinode when there is an active region that is likely to flare during our GREGOR observing time from June 27 until July 5.

In the standard flare model, electrons are accelerated in the corona and they precipitate into the lower solar atmosphere. They are assumed to be stopped in the chromosphere when the density becomes high enough. Hydrogen recombination emission, such as an enhanced Balmer continuum, is observed during this process and can be seen in IRIS observations (Heinzel & Kleint, 2014). Continuum emission is also seen from photospheric heights, even though the electrons are thought to be stopped significantly above, posing the question how energy is transferred in the solar atmosphere. One possibility is the so-called backwarming, which transfers energy to lower solar layers.

To investigate the effects of flare on the lower solar atmosphere in detail, spectral measurements throughout the UV, visible, and IR are required. The spectral shape and its evolution let us deduce the mechanisms of radiation (hydrogen recombination, H- continuum), the energy that goes into radiation can then be calculated and compared to the input energy of accelerated electrons derived from X-ray observations.

With IRIS, the NUV band can be covered to search for Balmer continuum emission. Hinode's SP adds points around 6302 A in the visible spectral range and GREGOR will be used for the IR. These data will be additionally combined with data from HMI and RHESSI. Compared to our first study of an X-flare (Kleint et al 2016), we would like to improve the coverage in the visible (with Hinode) to better constrain the blackbody-type enhancement and we would like to improve the cadence in IRIS to determine the onset and decay time of the continuum emission.

References: Heinzel & Kleint, ApJ 794, 23, 2014 Kleint et al., ApJ 816, 88, 2016.

Dates:

- ToO program from June 27 to July 5. We will alert the planners if a suitable target is available and propose pointing coordinates. - Minimum would be one co-observed flare, ideally several flares are desired.

Time window:

Very good seeing at GREGOR most often occurs from 8-10 UT. Good seeing can last from 7.30- 11.30 UT. Please schedule observations for 7.30-11.30 UT and in case of telemetry issues, prioritize 8-10 UT.

Start the observation at the end of orbital night, and finish at the beginning of orbital night to maximize telemetry. Interruptions for synoptics are allowed, but not desired.

Target(s) of interest:

Flares, i.e. complex active regions. ToO, we will alert planners if a suitable AR is available.

SOT Requests:

We request continuous IQUV SP rasters of the active region, centered on the neutral line where the flare is most likely to occur. Fast map mode. FOV depends on the size of the AR, estimated at ~100”x164”, ideally to be chosen such that the cadence is below 20 min. If telemetry does not permit continuous observations, please run as many rasters as possible (with temporal gaps).

Should FG be operational again during our observing run, then use B filter with fastest cadence possible.

EIS Requests:

Study to run: qub_hi-cad_flare_v2 (ID: 530), duration 1hr 2min

During eclipse season the CO should schedule one run of qub_hi-cad_flare_v2 per orbit. By default the study contains 17 raster repeats. This number should be adjusted to fit within the orbital daylight period.

The pointing should be centered on the IRIS pointing.

Note that qub_hi-cad_flare_v2 is a high date rate study that generates 245 Mbits of data per hour.

If the EIS obstbl upload interferes with the running of the study, then please check with the CP to move the upload to a different pass.

XRT Requests:

Run a flare program, to be chosen by planner.

IRIS Requests:

- 4 step raster to improve chances to catch flare ribbons, longest slit possible
- max 8 s integration
- AEC on, rotation tracking on
- SJI 1330 and 2700 (for AEC), 2832 for alignment to other instruments (e.g. GREGOR).
- full line list (would improve continuum coverage and may give new insights into Fe XXI emission), if telemetry not sufficient, choose flare linelist
- ideally do not bin (FUV ok to bin spectrally by 2)
- center slit on neutral line
- if telemetry too high, consider running large instead of very large rasters. See below for details on the telemetry. Priority is to run the very large or large runs with full readout. But if that is absolutely not possible, look below for alternative programs.

— high data rate options —
1st choice (We are aware that 2.5 Mbit/s is high, but this obs would achieve the highest science value. There are very few flare observations using the full linelist and because activity is declining, fewer and fewer chances to obtain them. Only the full linelist may show a high-velocity tail in Fe XXI emission and gives more spectral points for the Balmer continuum.)
3680258324 | Very large coarse 4-step raster 6x175 4s C II Mg II h/k Mg II w s | 115.42 | 431.41 | 2.5 | 9.6+/-0.1 | 38.5+/-0.1 | 23.5+/-8.6 | 0.0+/-0.0 | 19.2+/-0.1 | 115.4+/-0.0

2nd choice (flare linelist instead of full readout)
3660258324 | Very large coarse 4-step raster 6x175 4s C II Mg II h/k Mg II w s (1.5 Mbit/s)

if one flare successfully caught, try 2-step raster for next flare:
3660258314 | Very large coarse 2-step raster 2x175 2s C II Mg II h/k Mg II w s (1.5 Mbit/s)

— For smaller AR (“large” instead of “very large” rasters), medium data rates
3680258323 (1.6 Mbit/s) - first choice
3660258323 (0.9 Mbit/s) - second choice
3660258313 (0.9 Mbit/s) - second choice

— medium data rate for large AR —
(rather bin spatially and use “very large” instead of risking of not catching the flare)
3680338324 | Very large coarse 4-step raster 6x175 4s C II Mg II h/k Mg II w s | (1.3 Mbit/s)

— low data rate (only run if absolutely necessary) —
3660338323 | Large coarse 4-step raster 6x120 4s C II Mg II h/k Mg II w s Deep (0.5 Mbit/s)

If telemetry is not sufficient to run during the whole time frame, then run high telemetry program from 7:30-10 and medium telemetry from 10-11:30.

Additional instrument coordination:

GREGOR

Previous HOP information:

HOP 251

Publications: - L. Kleint, P. Heinzel, P. Judge, S. Krucker: "Continuum Enhancements in the Ultraviolet, the Visible, and the Infrared during the X1 flare on 2014 March 29", ApJ, 816, 88, 2016 - W. Liu, P. Heinzel, L. Kleint, J. Kasparova: "Mg II Lines Observed during the X-class Flare on 29 March 2014 by the Interface Region Imaging Spectrograph", SoPh, 290, 3235, 2015 - P. Judge, L. Kleint, A. Sainz Dalda: "On helium line polarization during the impulsive phase of an X1 flare", ApJ, 814, 100, 2015 - M. Battaglia, L. Kleint, S. Krucker, D. Graham: "How important are electron beams in driving chromospheric evaporation in the 2014 March 29 flare?", ApJ 813, 113, 2015 - L. Kleint, M. Battaglia, K. Reardon, A. Sainz Dalda, P.R. Young, S. Krucker: "The Fast Filament Eruption Leading to the X-flare on 2014 March 29", ApJ 806, 9, 2015 - P. Judge, L. Kleint, A. Donea, A. Sainz Dalda, L. Fletcher: "On the Origin of a Sunquake during the 2014 March 29 X1 Flare", ApJ 796, 85, 2014 - P. Heinzel & L. Kleint: "Hydrogen Balmer Continuum in Solar Flares Detected by the Interface

Region Imaging Spectrograph (IRIS)", ApJ 794, 23, 2014

Additional Remarks:

Hinode planners: please start the observation at the end of orbital night, and finish at the beginning of orbital night to maximize telemetry. Time window: 7.30-11.30. UT