JOP065: Inverse Evershed Effect (SUMER, CDS, EIT, MDI)

Contributors: I. Rüedi, S.K. Solanki, K. Stucki, A. Brković (ETH Zürich),
U. Schühle, K. Wilhelm (MPI, Lindau), R. Harrison,
A. Fludra (RAL), T. Hoeksema (Stanford),
J. Gurman (NASA/Goddard), M.C.E. Huber (ESA/SSD)

Scientific Justification

Sunspots are the seats of considerable dynamics. The most obvious are the Evershed and inverse Evershed effects.

The Evershed effect is characterised by line shifts in the penumbra and superpenumbra corresponding to a material outflow. These velocities can reach values of 6 km/s and are almost horizontal, following the magnetic field lines. Therefore they can only be observed at a certain distance from disc centre where the velocity vector has a significant component along the line of sight. The magnitude of the observed velocities depends on the spectral lines under consideration and is largest for the spectral lines originating most deeply in the atmosphere.

In the chromosphere and lower transition region, the velocities are directed outwards, this phenomenon is referred to as the inverse Evershed effect. The flow is also almost horizontal above the superpenumbra and becomes increasingly vertical towards the umbra. Both subsonic and supersonic velocities are observed. The subsonic velocities tend to increase with temperature, from less than 5 km/s observed in O I to 40 km/s in O V. The supersonic component is seen only in the transition region and is approximately 100 km/s, independently of the temperature at which it is observed. From the absence of supersonic flows at chromospheric temperatures, it is expected that the flow shocks at greater heights.

We propose to use SUMER and CDS to probe the Inverse Evershed effect and dynamic phenomena associated with brightenings in the sunspot or its superpenumbra, while MDI would in parallel provide information on the normal Evershed effect and the general magnetic structure of the sunspot and its surroundings. The different observed lines should give us considerable information to investigate the vertical and horizontal structure of these flows and possibly allow the detection of shocks.

Operational considerations

The target of the JOP is a sunspot located at an intermediate limb distance, in order to be able to detect both the almost horizontal and the almost vertical flows, while concurrently affording a certain spatial resolution in the direction perpendicular to the slit.

CDS will raster a 120” × 180” area centered on the sunspot. The approximate time for a raster is one hour. It should be repeated a few times in order to
an idea of the possible changes taking place in that region during the complete
time of the SUMER observations.

The SUMER slit will be positioned at different positions in the sunspot and
just beside it. At each position, 4 groups of spectral lines will be observed
while compensating for solar rotation. Then, the pointing will be reset and the
sequence started again.

MDI magnetograms and velocity data of the regions under study will be of
great value for obtaining a general picture of the sunspot. They will allow us
to get information on the normal photospheric Evershed effect of that sunspot,
while SUMER and CDS will provide information on the chromospheric inverse
Evershed effect. The magnetograms will also provide the magnetic context of
the sunspot’s structure.

EIT images will help to clarify the general structure of the active region ob-

Operational sequence

In order to be able to measure the fairly horizontal Evershed flow while retaining
a certain spatial resolution of the sunspot, this JOP should be run during the
period when SUMER is neither pointing at sun centre nor at the limb, i.e. in
May or June.

Due to the impossibility to predicting when a sunspot will be present in
the pointing range of SUMER, we propose to run this JOP as a target of
opportunity.

SUMER sequence:

Initial pointing: Sunspot to be determined
Step size: no rastering
Pixels per "spectral line": 120×1024
Compression: Quasilog (compression type 5)
Solar rotation compensation: yes
Co-operation requirements: copointing with CDS
Duration of the sequence: 29 minutes (according to the simulator)
Number of repetitions: 10 times
Total length of the study: 5 hours

Item 1:

Spectral lines: O V 758.678 Å (refpix 733)
Slit: 0.3×120 arc sec² (slit 6)
Integration time: 180 sec
Number of repetitions: 2
Duration of item: 6 minutes

Item 2:
Spectral lines: S III 1077.13 Å (refpix 350)
Slit: 0.3×120 arc sec² (slit 6)
Integration time: 180 sec
Number of repetitions: 2
Duration of item: 6 minutes

Item 3:
Spectral lines: O I 1306.03 Å (refpix 785)
Slit: 0.3×120 arc sec² (slit 6)
Integration time: 180 sec
Number of repetitions: 2
Duration of item: 6 minutes

Item 4:
Spectral lines: C I 1353.75 Å (refpix 610)
Slit: 0.3×120 arc sec² (slit 6)
Integration time: 180 sec
Number of repetitions: 2
Duration of item: 6 minutes

CDS sequence:
Initial pointing: Active region to be determined
Slit: 2×240 arc sec²
Spectral lines: He I 522.20 Å, O III 599.59 Å, O IV 554.29 Å, O V 629.73 Å, Ne VI 562.83 Å, Mg VIII 313.73 Å,
Mg IX 315.02 Å, Mg IX 368.06 Å, Mg X 624.94 Å,
Al XI 550.00 Å, Si XI 580.90 Å, Si XII 520.67 Å,
Fe XII 364.47 Å, Fe XIV 353.83 Å, Fe XIV 334.17 Å,
Fe XVI 335.40 Å
Raster step size: 2 arcsec
Number of raster step: 60
Raster area: 120 × 180 arc sec²
Dwell time: 60s
Points retained along the slit: 110 pixels
Width of spectral boxes: 28 pixels
Compression: 16 bits → 12 bits
Solar rotation compensation:
Duration of observation: 1 hours
Number of raster: 5
Total time of sequence: 5 hours
Cooperation requirements: Pointing with SUMER

**MDI sequence:**
Standard magnetograms and velocity data of the sunspot region observed with SUMER and CDS.

**EIT sequence:**
Full resolution images of all 4 spectral lines. If possible, high-resolution images of the active region would also be of interest.