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

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### 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" $\times$ 180" area centered on the sunspot. The approximate time for a raster is one hour. It should be repeated a few time in order to obtain 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 spectal 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 magnetogramms will also provide the magnetic context of the sunspot's structure.

EIT images will help to clarify the general structure of the active region observed.

**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 sec$^2$ (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 $sec^2$ (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 $sec^2$ (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 $sec^2$ (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 $sec^2$ |
| 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 VIII 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 $sec^2$ |
| Dwell time: | 60s |
| Points retained along the slit: | 110 pixels |
| Width of spectral boxes: | 28 pixels |

Compression: 16 bits $\rightarrow$ 12 bits
Solar rotation compensation: yes
Duration of observation: 1 hours
Number of raster: 5
Total time of sequence: 5 hours
Cooperation requirements: Copointing 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.