Dynamics of Minor Solar Activity
Coordinated Observations SOHO-GBO JOP #37

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Abstract. We present a program for coordinated observations between
ground based observatories, mainly NSO/Sacramento Peak, and several
instruments onboard SOHO (primarily SUMER). The scientific goal is
the study of small activity phenomena, at high spatial and temporal res-
olution.

1. Introduction

When observed at high resolution, both temporal and spatial, the solar atmo-
sphere displays an amazing variety of phenomena at small scales, in a continuous
dynamical evolution. An excellent demonstration of such a “dynamical Sun” is
given by the wealth of high resolution observations acquired with the instruments
onboard SOHO, described in several recent papers (see, e.g., the contributions
by F. Clette, T. Hoeksema, K. Wilhelm in this volume).

Among small scale phenomena, particularly interesting is the study of “mi-
nor activity”, i.e. of those impulsive and very localized episodes of energy release
($10^{28}$ ergs or less), occurring within active regions even of small dimensions. Small
impulsive events of this type (let’s call them “transient brightenings” as done
by Shimizu et al. (1992) to describe coronal events seen by Yohkoh/SXT) are
observed throughout the whole solar atmosphere, from the lower chromosphere
up to the transition region and corona (see, e.g., Canfield & Metcalf, 1987;
Zachariadis et al., 1987; Shimizu et al., 1994; Cauzzi et al., 1995; Porter et al.,
1995).
The study of minor solar activity can represent an efficient way to understand the physics of all solar activity. If indeed the physical conditions leading to the development of big events, such as flares, are the same that give rise to transient brightenings (see, e.g., Shibata, 1996), then it is reasonable to assume that in this last case a clearer identification of the cause-effect relationships could be obtained. The main idea behind this statement is that for small events only the basic mechanisms are at work, i.e. that no collective phenomena will alter the observables from their original values.

The main limitation of most existing studies of small activity is that they have been conducted at isolated height regimes, mainly because of the scarce availability of simultaneous, high resolution observations sampling an extensive vertical span of the solar atmosphere (there are of course exceptions, see e.g. Fontenla et al., 1994). The launch of the SOHO spacecraft (Domingo et al., 1995) in December 1995 offered a real opportunity to fill in this gap. SOHO carries a cluster of instruments capable of obtaining high resolution observations covering, at the same time, the full atmosphere. Combining these capabilities with high resolution observations from the ground, it will be possible to achieve a better understanding of the solar activity phenomenon.

We present in the following a project of coordinated SOHO-GBO observations (JOP #37) of minor solar activity, mainly of their dynamical properties. A test program was run in August 1996. The setup allowed a continuous height coverage of the solar atmosphere, maintaining the highest possible spatial resolution. On the ground, we used mainly the cluster of instruments of the NSO/Sacramento Peak Vacuum Tower Telescope (NSO/SP-VTT) and the NSO/Kitt Peak (NSO/KP-VTT) spectromagnetograph, while on board SOHO we primarily used SUMER (Wilhelm et al., 1995). The final program was scheduled in the period Oct. 14-20, 1996, and included SUMER, CDS, EIT and MDI on SOHO.

2. JOP #37 – Setup for Aug. 1996 Observations (Engineering Run)

2.1. Ground-based observations

Based on our previous experiences of the study of minor solar activity dynamics (Cauzzi et al., 1995; 1996a-b), we used the instruments at the NSO/SP-VTT to obtain images (with the tunable Universal Birefringent Filter-UBF) and spectra (with the Horizontal Spectrograph-HSG) at high resolution. Table 1 gives a summary of the observing setup. The field of view in the HSG row refers to a single slit exposure; the instrument could perform raster scans of extended areas, with a variable step. The spectral scan around CaII K includes also the Si I 3905 Å line, that is very sensitive even to the slightest sign of activity. Beside the NSO/SP-VTT data, magnetographic area scans from the NSO/KP-VTT have been performed for this program.

2.2. SOHO-SUMER Setup

Among the instruments onboard SOHO, SUMER represents the most obvious connection with ground-based observations, since it can reach a spatial resolution of about 1”, i.e. at the limit of good seeing at the ground. Moreover,
DYNAMICS OF MINOR SOLAR ACTIVITY

Table 1. Summary of the observations of JOP #37.

<table>
<thead>
<tr>
<th>Instrument</th>
<th>FOV</th>
<th>Spat. resol.</th>
<th>Observing $\lambda$ (Å)</th>
<th>FWHM (Å)</th>
<th>$\Delta t$ (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>UBF</td>
<td>$2' \times 2'$</td>
<td>$0.5'' \times 0.5''$</td>
<td>5889.9 (NaD$_2$)</td>
<td>0.2</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>5875.6 (HeI D$_3$)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>6562.8 (H$\alpha$)</td>
<td>0.25</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>6561.3 (H$\alpha + 1.5$ Å)</td>
<td>0.25</td>
<td></td>
</tr>
<tr>
<td>Zeiss</td>
<td>$2' \times 2'$</td>
<td>$0.5'' \times 0.5''$</td>
<td>6564.3 (H$\alpha + 1.5$ Å)</td>
<td>0.25</td>
<td>2.5</td>
</tr>
<tr>
<td>White Light</td>
<td>$2' \times 2'$</td>
<td>$0.5'' \times 0.5''$</td>
<td>5500</td>
<td>100</td>
<td>2.5</td>
</tr>
<tr>
<td>HSG</td>
<td>$0.75'' \times 2'$</td>
<td>$0.75'' \times 0.36''$</td>
<td>3904–3941 (CaII K)</td>
<td>0.035</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$0.75'' \times 0.13''$</td>
<td>4094–4108 (H$\delta$)</td>
<td>0.011</td>
<td></td>
</tr>
<tr>
<td>SUMER</td>
<td>$2' \times 2'$</td>
<td>$1'' \times 1''$</td>
<td>1026 (Ly$\beta$, $\sim 2 \times 10^4$ K)</td>
<td>105</td>
<td></td>
</tr>
<tr>
<td>(Raster scan)</td>
<td></td>
<td></td>
<td>1032 (O VI, $\sim 3 \times 10^5$ K)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

SUMER can observe spectral lines formed at very different heights of the solar atmosphere, from the relatively cold high chromosphere (e.g. Ly$\beta$, formed at an average temperature of about $2 \times 10^4$ K), up to the corona. This is an extremely important capability, because it provides a clear way to combine ground based data such as H$\alpha$ with data from upper layers. For our program, this will make it possible to monitor the small scale activity phenomena occurring at the photosphere and relate their effects at coronal levels and vice versa.

For the first run of JOP #37 we chose to use only two spectral signatures: Ly$\beta$ (1026 Å, for the reasons outlined above) and O VI (1032 Å, formed at $\sim 3 \times 10^5$ K, in the transition region). These two lines are quite strong in the UV spectrum, so we could set a low exposure time (1 s); we chose moreover to transmit not the full spectrum but only the line profile moments, to increase the overall temporal resolution. This resulted in about 100 s for a full raster scan of $2' \times 2'$ (see Table 1).

![Ly beta](image1.jpg) ![O VI](image2.jpg) ![O VI - velocity](image3.jpg)

Figure 1. Ly$\beta$ and O VI line center intensity maps, and O VI velocity map, obtained with SUMER on Aug. 15, 1996. FOV is $2' \times 1.8'$. 

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Figure 2. NOAA 7984 observed on Aug 15, 1996, around 14:50 UT, with the cluster of instruments at the NSO/VTT.
3. Discussion

We obtained data on a test run in August 1996 (14 – 19) with the setup described in Section 2. Fig. 1 gives an example of the SUMER data, while Fig. 2 represents a “snapshot” of some of the data collected at any given time with the GBO setup. The lower right corner of the SUMER FOV is indicated in the Hα image of Fig. 2 with white lines.

One can notice how the brightest structures in Hα line center are easily recognizable in the Lyβ image. This allows a very good superposition of the ground based data with the SUMER ones. Although the O VI intensity map still shows some correspondence with the Hα bright structures, an overlap between the two images would not be very accurate. Features visible in the O VI intensity map are sharper, and thinner (many of them are only a few arcsec across), than the ones visible in Lyβ. Quite interestingly, several of these rather thin, bright structures in O VI appear to coincide with darker “loops” seen in the Hα image. Some of these filamentary structures are clearly visible in the velocity images as well.

During the October final run of JOP#37 the Sun did not cooperate, and remained absolutely quiet throughout the whole observing period. We decided to target the quiet network, in cooperation with JOP #22 and with the MDI 90 hours continuous high resolution tracking (started on Oct. 18). The GBO setup was slightly modified in order to have a better spatial resolution for studying the very fine structures of the quiet Sun (we used 0.15" pixel size). The SUMER raster scan of the area around Sun center was obtained letting the Sun drift under the spectrograph slit, because of a problem with the pointing capabilities of the instrument. During this cooperative October run, simultaneous high resolution observations were also obtained from MDI, EIT and CDS onboard SOHO. They provided magnetic maps, and images and spectra in several lines, formed from the transition region up to the corona.

At the moment of writing, we just started the compared analysis of all these data.

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References

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