Hinode SOT Observations - First Preliminary Analysis

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Abstract.
In this paper we present some preliminary analysis of Hinode-SOT data: time series as well as synoptic data. We show that the data are influenced by periodic intensity variations as well as bad images appear. This should be taken into account when analysing the data.

Key words: Hinode - SOT - photosphere - fine structure observations

1. Introduction

Hinode is a Japanese mission developed and launched by ISAS/JAXA, collaborating NAOJ, NASA and STFC (UK). The operation of the Hinode mission is conducted by the Hinode science team organized at ISAS/JAXA. Support for the post-launch operation is provided by JAXA and NAOJ (Japan), STFC (U.K.), NASA (U.S.A.), ESA, and NSC (Norway). It was launched successfully on Sep. 22, 2006. We are interested in solar granulation observations of high resolution. Therefore, Solar Optical Telescope, SOT (50 cm diameter, diffraction limited images (0.2-0.3") in 388-668 nm range), data in the blue continuum band will be used here. The image stabilization system consists of a piezo-driven tip-tilt mirror in the optical tube assembly in a closed-loop servo using a displacement error estimated from correlation tracking of solar granulation (correlation tracker, CT).

The sun-synchronous orbit of Hinode allows a downlink of data nearly every orbit and hence observations will be possible 24 hours a day for about
8 months of the year. From its orbit an eclipse season has to be expected from May 9 to August 3 in 2007. Maximum duration of the eclipse will be less than 20 min in the 98-min-orbit of Hinode.

2. Data

Since we are interested in photospheric data with high spatial resolution we downloaded (from the Hinode DARTS site) individual images from the synoptic observations and time series in the blue continuum band (centred at 450.45 nm, BFI, bandwidth 0.4 nm). The full field of view of the 4096×2048 CCD detector covers 218×109". The exposure times were given between 0.03 and 0.8 s. The finest spatial scale available is 0.0541 arcsec/pixel.

3. First Analysis

3.1. Autocorrelation Function

The autocorrelation function (ACF) provides a very simple and easy to calculate measure for the size of granulation (see Muller, Hanslmeier, and Saldaña-Muñoz, 2006 or Muller, Saldaña-Muñoz, and Hanslmeier, 2006). We wanted to check whether this function remains constant over one solar rotation or not. In Figure 1 we give the results of the calculated 2-D autocorrelation function. To obtain the 2-D ACF, the 1-D ACF was calculated and then the image was rotated by 10 steps which proved to be sufficient. More steps did not lead to different results. The data are from the solar disk centre, and a subfield of 2048×2048 pixels was selected. The ACF was calculated and for different values at $y = 0.4$, 0.6, and 0.8 the resultant $x$-values were plotted. The question for further investigations is whether these fluctuations are of solar origin indicating different sizes and scales of solar granulation on the different dates or whether there are other influences. We give in Figure 1 examples of the part "left" (i.e. pixels 0...2047, 0...2047) and "right" (i.e. pixels 2048...4095 and 0...2047) of the CCD.

If the variations we observe are purely solar then there should be no correlation between the left and right part of the CCD, however due to solar rotation signals on the right side should appear on the left side with some delay. Such a behaviour is hardly seen in the data, however the noise clearly increases after May 10th.
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Figure 1: Comparison of left and right parts of the CCD.

Figure 2: Example of smoothed data, parameter = 5. The values of the ACF increase.

A closer inspection of the images shows that the sharpness and contrast is not the same. We can artificially simulate defocused images by introducing a smoothing parameter to the data (Figure 2, smoothing over 5 neighbouring points). This example demonstrates the effect of defocused images on the results, the ACF clearly increases because smaller structures are smeared out.

3.2. Time Series

In Figure 3 we calculated intensity variations, the \( \text{rms} \) intensity fluctuation, \( I_{\text{rms}} \) (first row of images) and from the Fourier analysis the \( I_{\text{rms}} \) fluctuation and the median value of the wavenumber \( k \) in the typical domain of granulation from 0.3 to 4.0 arcsec spatial scale. We see that \( I_{\text{rms}} \), \( k_m \) (median \( k \)-value) and \( I_{\text{rms}} \) calculated from power spectra show fluctuations with a
Figure 3: Example of time series (June 29th, 2007) of Hinode SOT data.

period of $\sim$90 min which corresponds to the orbital period of Hinode.

4. Conclusions

The preliminary analysis of Hinode-SOT data have shown:
Great stability of pointing (not shown here). Differences between individual images on different days. Some images appeared defocused, others with very high noise. One has the impression that the left part (with pixels 0...2047, 0...2047) of the 4096 pixel CCD has better image quality (images appear sharper and with more contrast). The time series of June 29th showed intensity variation in the same period as the orbital period of the satellite. The fluctuations seen in the data for the autocorrelation function are not purely of solar origin. This has to be accounted for in further data analysis.

References

