Mem. S.A.It. Vol. 80, 278

Memorie della

Observations of small-scale flux evolution with HINODE

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Abstract. We present observations of NOAA 10971 acquired by the Solar Optical Telescope onboard the HINODE satellite. We have inverted spectropolarimetric data of SOT/SP along Fe I doublet at 630.15 nm and 630.25 nm, using the SIR inversion code in order to get magnetic field strength, inclination, azimuth, Doppler velocity and temperature from the observed Stokes profiles. We compare these first results with SOT/FG broad-band observations in the Ca II H line (396.85 ± 0.3 nm) and G-band (430.5 ± 0.8 nm), and with magnetograms obtained from the narrow-band shuttered Stokes I and V in the wings of the Na I D1 line (589.6 nm). Small-scale events of flux emergence and flux cancellation have been singled out.

Key words. Sun: activity – Sun: photosphere – Sun: chromosphere

1. Introduction

The evolution of an active region during the long decay phase is dominated by small-scale events (van Driel-Gesztelyi 2002), like the cancellation of patches of opposite polarity (Bellot Rubio & Beck 2005) and the interaction of the ambient magnetic field with newly emerging flux (Zuccarello et al. 2008). Due to the capabilities offered by high resolution instruments, such small-scale evolution is object of an increasing interest.

Using observations performed by the *Hinode* satellite, we have investigated small-scale flux dynamics by means of spectropolarimetric data, comparing the results with high resolution filtergrams.

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2. Observations and data analysis

During the Hinode Operation Plan 14, in a joint campaign with solar telescopes in Canary Islands, on 30 September 2007, the active region NOAA 10971 was observed by SOT telescope (Tsuneta et al. 2008) onboard HINODE (Kosugi et al. 2007), at an heliocentric angle of 11°. We analyzed the complete Stokes I, Q, U, and V profiles acquired by SOT Spectropolarimeter (SP) along the Fe I lines at 630.15 nm and 630.25 nm, during six scans of the active region from 08:00 to 14:00 UT.

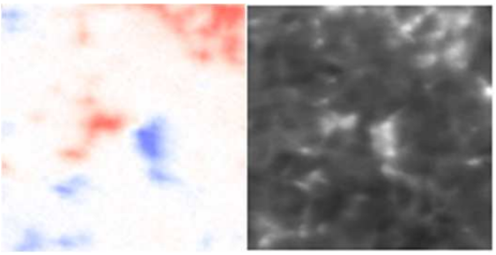

Fig. 1. On the left, a magnetogram obtained from Na I D1 line, at 09:00 UT. The two cancelling regions of opposite polarity are easily recognized. The FOV is 10×10 Mm^2. On the right, an image of the same region in chromosphere in Ca II H line core, where we notice a chromospheric brightness enhancing.

The field-of-view (FOV) of SOT/SP is $164'' \times 164''$, in Fast Map mode, with a spatial resolution of $0.32''$. Moreover, we analyzed the SOT filtergrams provided by the Broad-band and Narrow-band Filter imagers (FG), in the core of the Ca II H line (396.85 ± 0.3 nm) and G-band (430.5 ± 0.8 nm), with a FOV of $218'' \times 109''$ and a spatial sampling of $0.05''$/pixel in G-band and $0.1''$/pixel for Ca II H line, and shuttered Stokes I and V in the wings of the Na I D1 line (589.6 nm), from which we obtained magnetograms, with a FOV of $328'' \times 164''$ and a spatial sampling of $0.16''$/pixel. All SOT/FG images have a cadence of one minute from 07:00 UT to 17:00 UT.

We corrected SOT/SP and SOT/FG images for dark current, flat field and cosmic rays using SolarSoft routines. For SOT/SP data, we choose a reference profile searching the minimum of the total polarization and obtaining Stokes I, Q, U, V profiles, normalized to the continuum and corrected for limb darkening. We inverted these profiles using the SIR inversion code (Ruiz Cobo & del Toro Iniesta 1992).

3. Results and conclusions

An event of magnetic flux cancellation between two regions of opposite polarity, with sizes of ~ 3 Mm^2, was observed from 08:30 UT to 10:30 UT, with a simultaneous chromospheric brightness enhancing in the region. The net flux disappearance is $\sim 2 \cdot 10^{19}$ Mx. We see two images of the canceling patches in Fig. 1.

Flux emergence events have been also noticed, as the appearance of a bipolar region within the active region. During this event, we have noticed a chromospheric brightness enhancing in Ca II H line, pointing out for interaction occurring between the new and the old flux systems. The emerging bipolar region shows an emergence zone, i.e. a region between the two main polarities with horizontal fields and upflows of ~ 1 km s^{-1}, while footpoints have a vertical zenith angle, high field strength and downflows of $\sim 1.5 - 2$ km s^{-1}.

To summarize, we point out that the analysis of these observations revealed a number of small-scale events related with the evolution of active regions. Flux cancellation and flux emergence shape the dynamics of the active region NOAA 10971 during its decay phase, leading to small but continuous changes in the magnetic configuration.

Acknowledgements. We wish to thank all the scientists of HINODE/SOT team for their continuous support. HINODE is a Japanese mission developed and launched by ISAS/JAXA, with NAOJ as domestic partner and NASA and STFC (UK) as international partners. It is operated by these agencies in co-operation with ESA and NSC (Norway). We acknowledge financial support from the Spanish Ministerio de Educación y Ciencia through project ESP2006-13030-C06-02 and Programa de Acceso a Infraestructuras Científicas y Tecnológicas Singulares (ICTS). Financial support by the European Commission through the SOLAIRE Network (MTRN-CT-2006-035484) is gratefully acknowledged.

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