Photospheric Flow Field Related to the Evolution of the Sun's Polar Magnetic Patches Observed by Hinode SOT

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The distribution and evolution of the Sun's polar magnetic field is of vital importance to understand the origin of the solar magnetism, its periodic variation and the heliospheric magnetic flux. Recent high resolution observations from the Hinode satellite have revealed that the polar region is dominated by unipolar magnetic patches which possess magnetic fields with field strengths exceeding 1 kG. The basic properties, mechanism of formation and reversal of the polar magnetic fields are topics which are yet to be resolved.

To investigate the role of photospheric flow fields in the formation and evolution of the polar magnetic patches, we conducted spectro-polarimetric observations with Hinode SOT-SP in the north and south polar caps on 2013 Nov 11, 2013 Nov 13, 2013 Dec 08, 2013 Dec 11, 2014 Jan 17, 2014 Jan 23 and 2014 Mar 08. The SP recorded full Stokes spectra of the two Fe I lines at 630.15 nm and 630.25 nm with the fast map mode whose slit-scanning step is 0.32″ and integration time in each step is 3.2s. Image sequences were obtained with a cadence of 16 minutes and the FOV was 80″×164″. Photospheric vector magnetic fields were derived by Milne-Eddington inversion for those pixels with Stokes Q, U or V peaks larger than 5 sigma. The variation of the flows with height was examined by the bisector analysis of the Fe I 630.15 nm line profile at four line depths.

We found many unipolar appearances and disappearances in the data. Converging horizontal flows are observed outside the magnetic patches during the entire lives of the patches. The converging flow is best observed at a height close to the solar photosphere. We also observed a weak converging flow around the retraced patch location 16 minutes before the patch appearance. The result implies that polar magnetic patches are formed by the accumulation of flux fragments by the horizontal converging flows. In addition to direct cancellation between opposite polarity patches, we observed unipolar disappearance of polar patches. We speculate that these patches diffuse away into smaller fragments with flux below the detection limit of the instrument and eventually undergo cancellation with opposite polarity fragments.

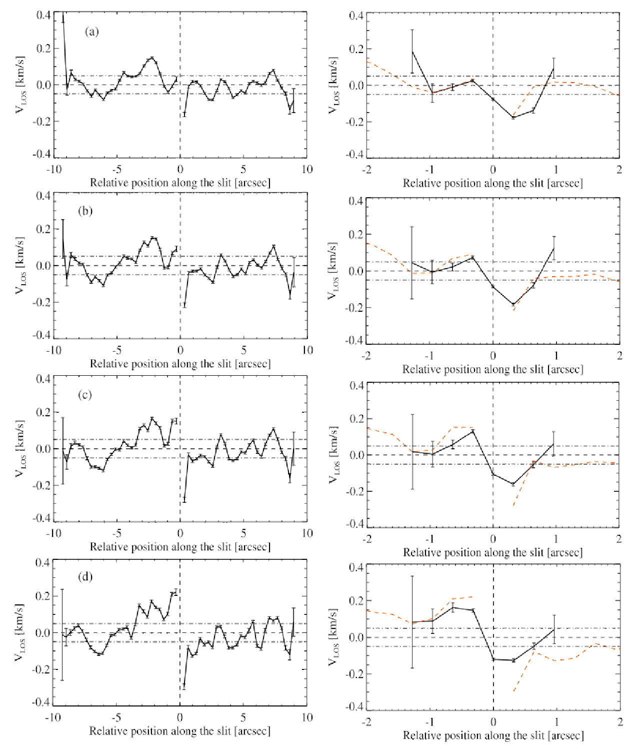

Figure 1: The average Doppler velocity profiles along N-S direction indicating converging flows at line bisector positions in the order of line intensity from top to bottom panel at time of patch appearance. The plots on the left panel represent horizontal velocity field outside the patch and that on the right represent the velocity field within the patch.

Reference

[1] Kaithakkal, A. J., Suematsu, Y., Kubo, M., Iida, Y., Shiota, D., Tsuneta, S.: 2015, *ApJ*, **799**, 139.