Highlights of Spanish Astrophysics VII, Proceedings of the X Scientific Meeting of the Spanish Astronomical Society held on July 9 - 13, 2012, in Valencia, Spain. J. C. Guirado, L.M. Lara, V. Quilis, and J. Gorgas (eds.)

Small magnetic bright structures in the quiet Sun

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Abstract

This work aims at further developing our knowledge of the ubiquitous small scale magnetic structures of the solar surface, focusing on the poles of the Sun. To get a clearer view of the situation at the very high latitudes, we make use of the inclination of the solar axis with respect to the ecliptic.
We find the known continuous decrease of the area covered by bright points from centre to limb. However, when the solar rotation axis is inclined toward us there is an increase in bright points areas coverage near the limb, i.e. near the poles.

1 Introduction

Within our continued study of the quiet Sun regions, we attempt to prefigure some of the information that will be possible to obtain from observations that will be obtained by the Solar Orbiter mission. The orbit of Solar Orbiter after the initial phase will reach an inclination of 30°, thus allowing a more direct observation of the solar polar caps.

We use the fact that the solar rotation axis is inclined $7^{\circ}\!.25$ respect to the ecliptic to study an aspect of the solar polar cap. During the months of March and September, the poles of the Sun are more directly in sight from Earth.

Our effort consists in studying the centre to limb variation (CLV) of the fraction of covered surface (FCS) by small magnetic elements on the solar phostophere. This is performed by analysing bright points (BPs) in observations at the moment when Earth reaches the highest latitude, which includes part of the polar cap, taking place during the months of March and September.

2 Observation and data preparation

The data analysed in this work was observed with the Solar Optical Telescope (SOT) [2] onboard *Hinode*. It corresponds to Quiet Sun inter-network regions away from active areas. We have used G-band images (4305 Å; FWHM 8Å) adquired by the Broadband Filter Imager (BFI) belonging to the months of March and September from 2007 to 2011. The observed FOV covered $223''.15 \times 111''.58$ correspondig to 2×2 binned images with an original spatial scale of $0''.05448\ pix^{-1}$. For each month, a set of data was selected at different latitudes in the central meridian of the Sun. The images were corrected with the basic procedures for Hinode data to substract dark-current and flatfielding. They were also corrected from limb darkening.

We have obtained the fraction of solar surface covered by BPs in each image. We have only considered structures with an intensity greater than four standard desviations in each image. The FCS is defined as the ratio between the number of pixels corresponding to the area covered by the selected structures and the total number of pixels in the image. With this method, some structures different to BPs, like bright areas of granules, have been included and moreover, we have overlooked the weaker ones. However, this method has allowed the analysis of a large dataset in a semiautomatic way, yielding similar results to others in the literature that need a more dedicated handling, like [1].

3 Results

The results have been organized by averaging the FCS corresponding to a same latitude in one degree steps. In Figs. 1 and 2, we present the results for the different months and years over which we have performed our study, with the FCS shown as function of latitude. Error bars signifying this latitudinal range and the FCS standard deviation are not drawn for the sake of clarity.

In these figures, it can be seen a general trend of the FCS decreasing monotonically from disc centre to the poles with values going from around 0.8% to 0.2-0.1%. This behaviour has been observed also in previous works analysing the CLV of the FCS of BPs, like [1]. The values we have obtained for the FCS are lower than the ones obtained by [1] and other preceding analyses. This difference probably comes from the method used to select BPs, although the influence of different instruments and postprocessing techniques used in the observations also has a strong influence.

However, what was not observed in those works is the increase on the very limit of the latitudes. This rise can be seen in all the figures, corresponding for each of them to the pole, North or South, that was more prominently facing Earth at the time of observation. Previous works were not aware of this phenomena because the observations did not reach the highest latitudes or because of the time of their observations, away from the March and September windows were the Sun-Earth inclination effect is more important. Other reasons for this

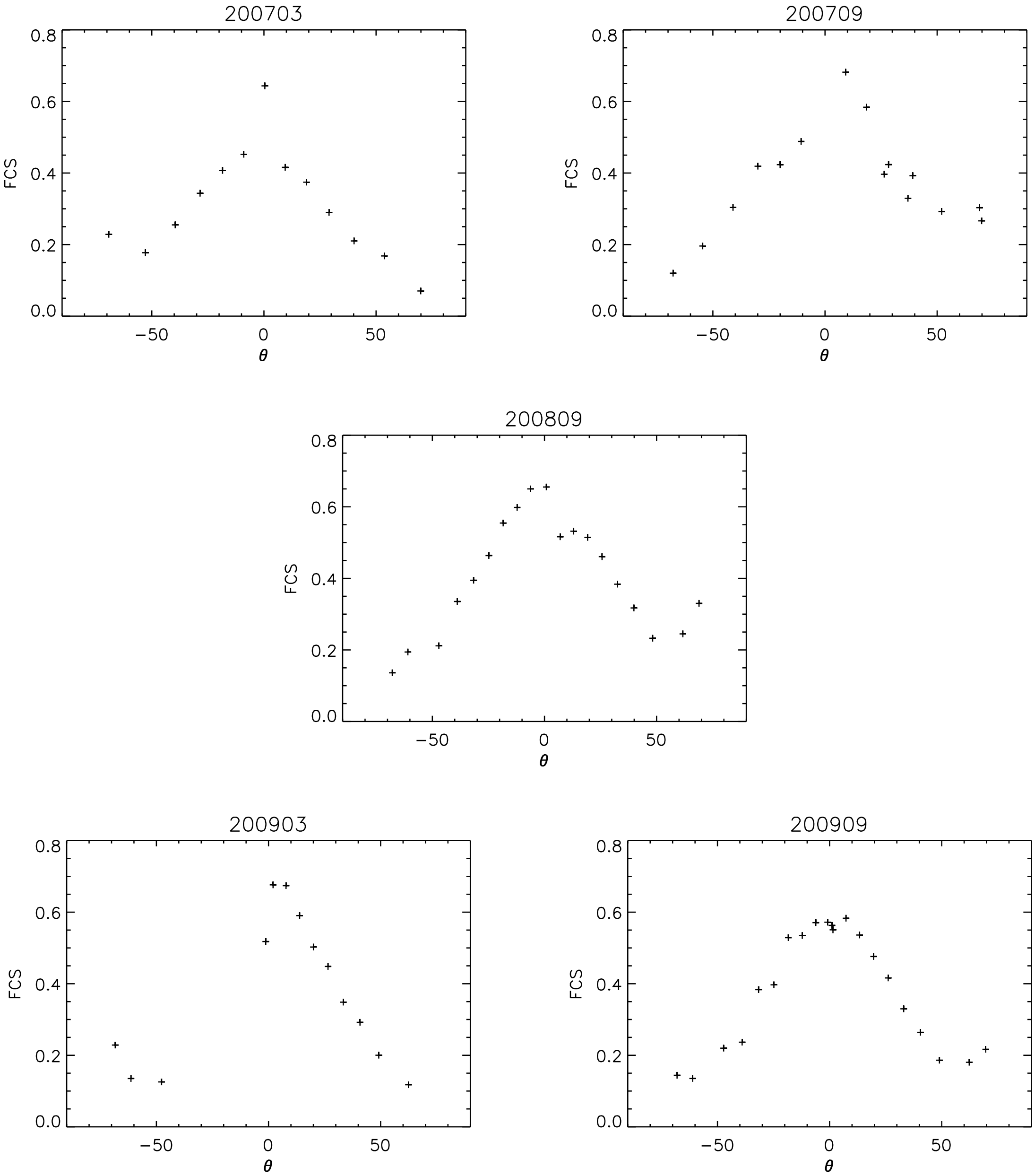

Figure 1: Fraction of covered solar surface occupied by bright points versus latitude at central solar meridian for the months of March and September from 2007 to 2009, except March 2008. Each asterisk corresponds to the average FCS value of all the FOVs around the same latitude.

discrepancy may come from the different spatial resolutions and/or different BP selection method in the studies, as was pointed out above with the difference in FCS values.

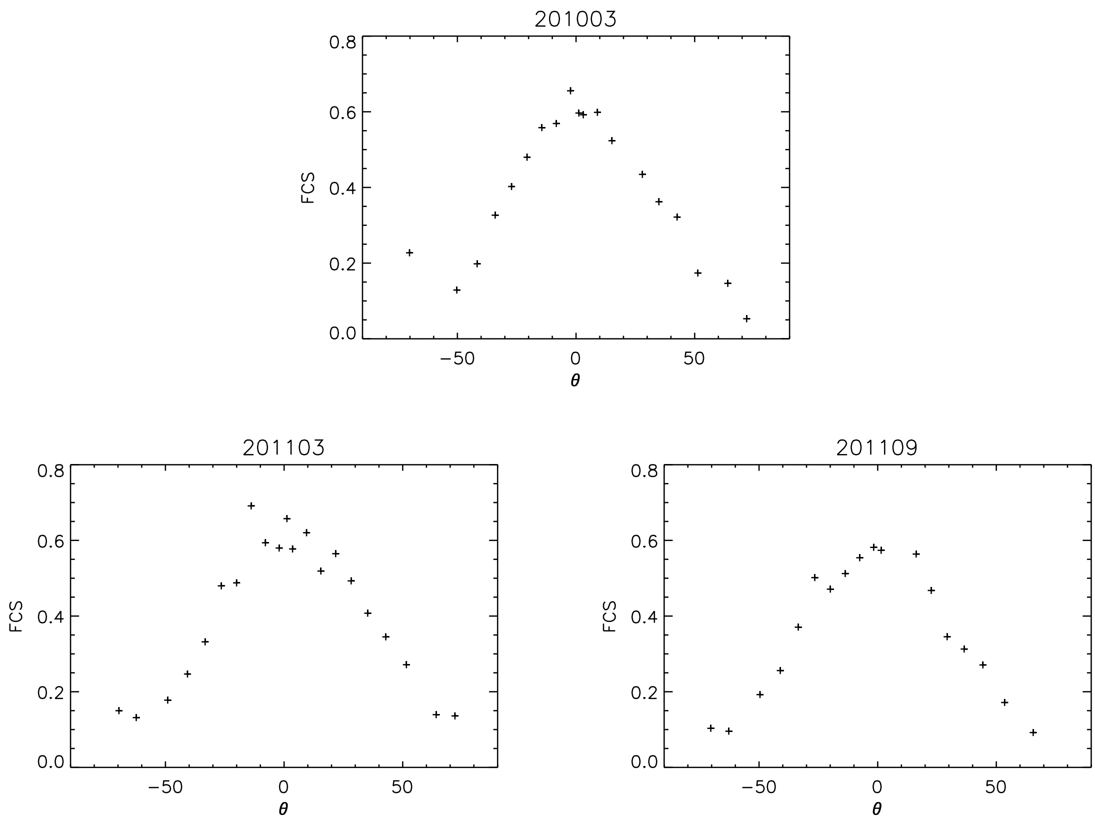

Figure 2: Same as 1 but for years 2010 and 2011, except September 2010.

4 Conclusions

This work has hint at the important role that small scale magnetic structures play at the poles of the Sun. While this role will become much more evident and accesible to study when Solar Orbiter is launched, further analyses shall be performed in the meantime.

Further improvement of selection method should give closer values to previous works along with a more reliable BPs collection.

References

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