Long-Term Datasets for the Understanding of Solar and Stellar Magnetic Cycles
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Association of calcium network brightness with polar magnetic fields

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Abstract. Recent dedicated *HINODE* polar region campaign revealed the presence of concentrated kilogauss patches of magnetic field in the polar regions of Sun which are also shown to be correlated with facular bright points at the photospheric level. In this work, we demonstrate that this spatial intermittency of the magnetic field persists even up to the chromospheric heights. Polar network bright points are the ones which are present in the polar regions of the Sun (above 70° latitudes). We use special *HINODE* campaigns devoted to observe polar regions of the Sun to study the polar network bright points during the phase of last extended solar minimum. We are able to find a considerable association between the polar network bright points and magnetic field concentrations which led us to conclude that these bright points can serve as a good proxy for polar magnetic fields where the direct and regular measurements of polar magnetic fields are not available (before 1970).

Keywords. Sun: chromosphere, photosphere, magnetic fields

The chromospheric network is a web-like pattern most easily seen as emission feature in the red line of hydrogen (Hα) and the violet lines of calcium (Ca II K and Ca II H) images of Sun. This pattern or network is believed to be coincident with the boundaries of large-scale convective cells, known as the supergranules, each about 20-60 Mm in diameter (Rieutord and Rincon, 2010). Simon and Leighton (1964) found a one-to-one correlation in the position of supergranules and bright network seen on Ca II K line spectroheliograms. The supergranular convective flow across photosphere, pushes the magnetic elements towards the supergranules boundaries, so a network of magnetic field is formed. At these points the magnetic field appears comparatively enhanced, resulting in coinciding network bright points recognisable in Ca II lines. Network bright points observed in polar regions of Sun are referred as polar network bright points. They populate higher heliographic latitudes above 60° or 70°.

We have used Ca II H passband images along with co-spatial and co-temporal level 2 spectro-polarimetric data observed by SOT. Analyzing different datasets (8 in total) in polar regions of the Sun, we have explored the possibility of the network bright point intensity to be considered as magnetic field proxy.

We find that the network bright points, as seen in Ca H images are almost always associated with the magnetic patches as seen in the photosphere. Their sizes are $\sim 1'' - 5''$. Figure 1 shows that the value of the magnetic field strength can reach up to 700 Gauss within the bright points. Tsuneta *et al.* (2008) and Kaithakkal *et al.* (2013) have also reported the values of a few kG in concentrated magnetic patches. In the past era, the low-resolution observations were unable to detect these small-scale locations of strong magnetic field strengths which is now possible with enhanced resolution data like SOT spectro-polarimetric observations. Along with considerable spatial association observed

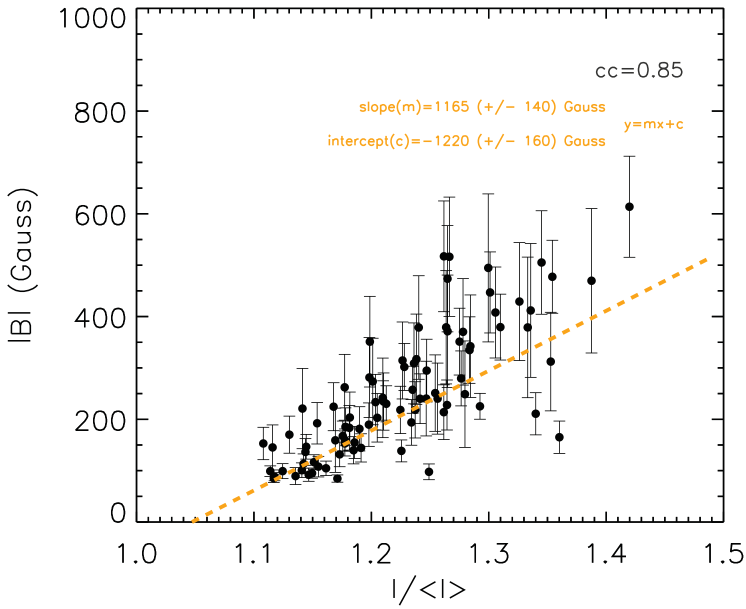

Figure 1. Scatter plot between normalised Ca H intensity (I / < I >) and magnetic field strength (| B |) for all the 88 bright points detected in the 8 data-sets. Every point in the plot represents the respective values averaged each bright point region. cc indicates the correlation coefficient, m indicates the slope and c indicates the intercept.

between network bright points and magnetic patches, we find that a good correlation exists between bright point intensity and magnetic field strength.

Based on such observations, we can conclude that the polar network brightness can serve as a good proxy for polar magnetic fields. We have proposed a linear relation between normalised Ca H intensity and magnetic field strength of the polar network bright-points, which can be employed for determining the strength of the polar magnetic fields for the historical era. In near future, further investigations can be done in this context to check the effectiveness of this proxy for determining polar magnetic fields by using long-term and continuous Ca II H or K observations of Sun's polar region.

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