16th European Solar Physics Meeting

ANALYSIS OF CANCELLATION INDEX IN PHOTOSPHERIC MAGNETIC FIELDS ASSOCIATED TO CORONAL HOLES

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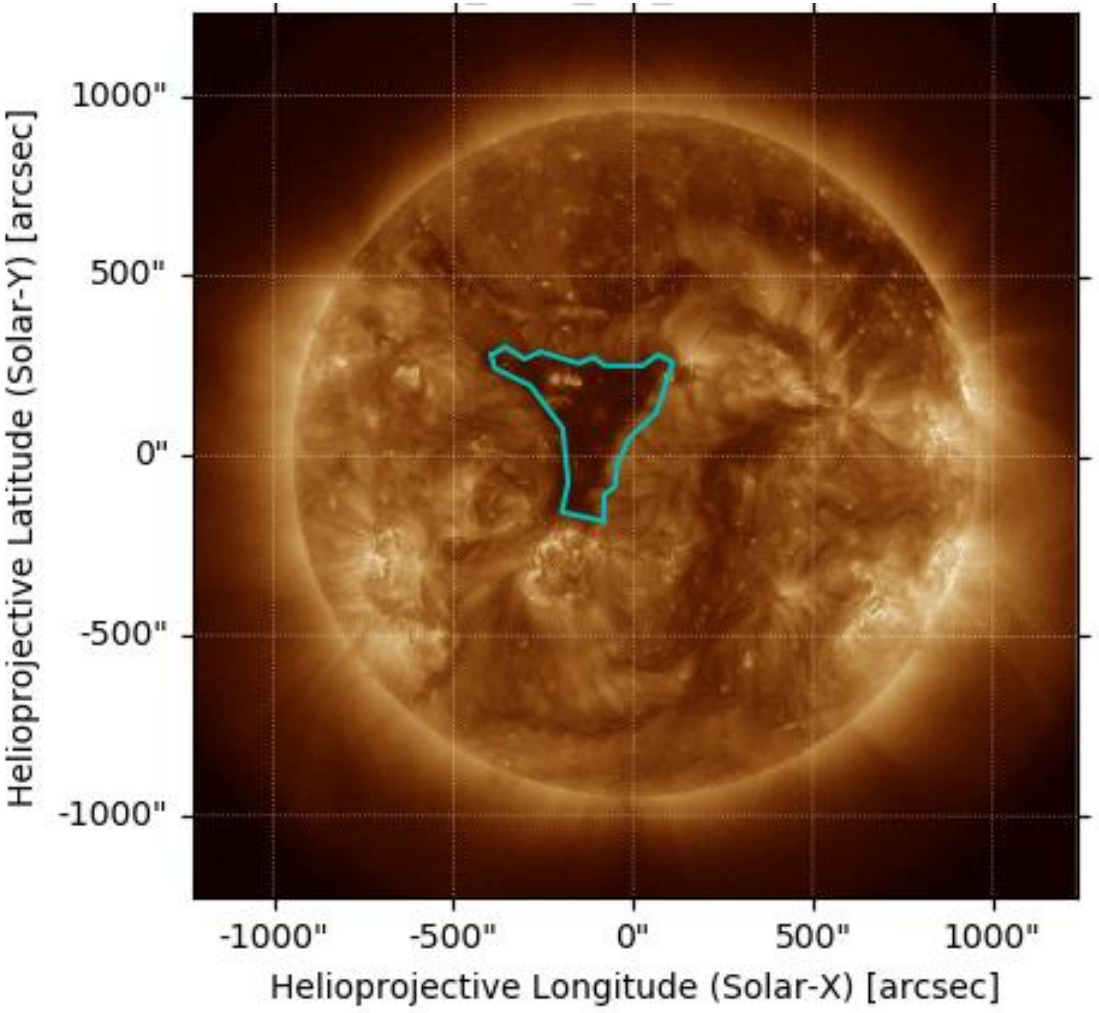
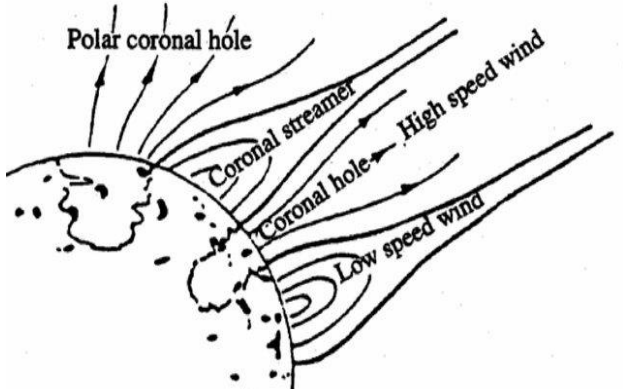
Coronal Holes (CHs)



- CHs are regions of low-density plasma, which appear dark in images of the Corona acquired in EUV/soft-X lines, that have magnetic fields opening freely into the heliosphere (Cranmer, S.R. Coronal Holes. Living Rev. Sol. Phys. 6, 3, 2009)
- CHs overwhelm photospheric regions with unbalanced magnetic fields.
- Since the CHs are sites from which fast solar wind is generated their interest is twofold *i)* to understand the dynamics of our star and *ii)* for applications in the field of Space Weather.



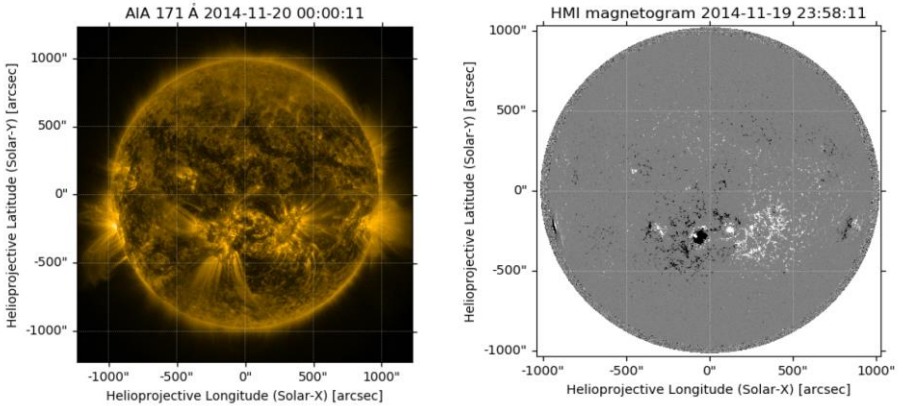
Adapted from: "The effect of a Fisk-Parker hybrid magnetic field on cosmic rays in the heliosphere" Tjaart P.J. Krüger

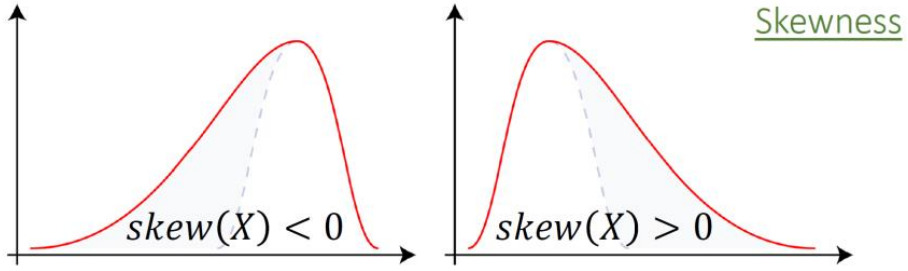
Analysis scheme

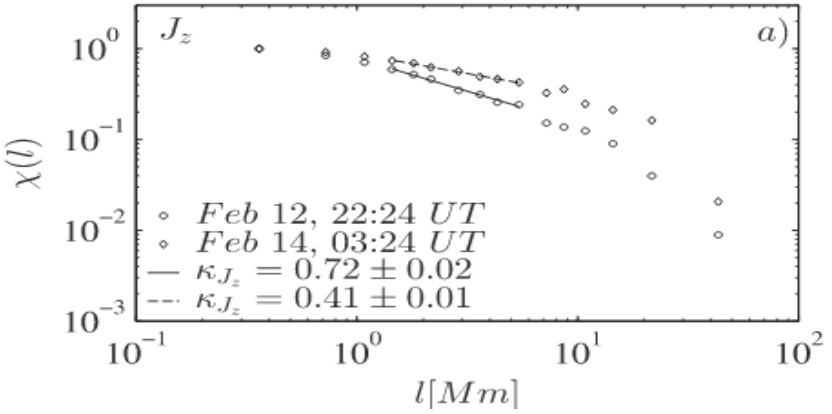
- Regions of interest (ROIs) with CHs (CHs) and without CHs (NCHs) were selected using SDO/AIA images. The ROIs selected for the analysis were superimposed on B_{LoS} magnetograms from SDO/HMI for the study of the properties of the photospheric magnetic field. In total, 60 CHs and 60 NCHs were analyzed.

- To estimate the properties of the photospheric magnetograms underlying the different ROIs (CHs and NCHs) two types of analysis were performed: *i)* the classical study of the standardized moments (e.g., *mean*, *skewness*) of the B_{LoS} distribution; *ii)* Signed measure and cancellation analysis of the magnetograms underlying the ROIs. Skewness is a measure of the asymmetry of the B_{LoS} distribution about its mean.

- The signed measure characterizes the scaling properties of sign oscillations (or sign persistence) of the B_{LoS} fields (*Ott + 1992, Sorriso-Valvo + 2015*).







The signed measure

Consider a field *f(r)* and its domain *Q(L)*. Let be *Qi(l)⊂Q(L)* a partition of *Q(L)* in disjoint subsets of size *l*.

The signed measure is:

$$\mu_i(l) = \frac{\int_{Q_i(l)} dr f(r)}{\int_{Q(L)} dr |f(r)|}$$

The cancellation function can be calculated as:

$$\chi(l) = \sum_{Q_i(l)} |\mu_i(l)|$$

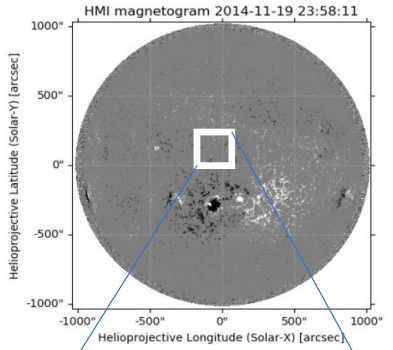
For fields which satisfy the property of self similarity, the above equation follows a power law (*Lawrence, Ruzmaikin, and Cadavid, 1993*):

$$\chi(l) = l^{-k}$$

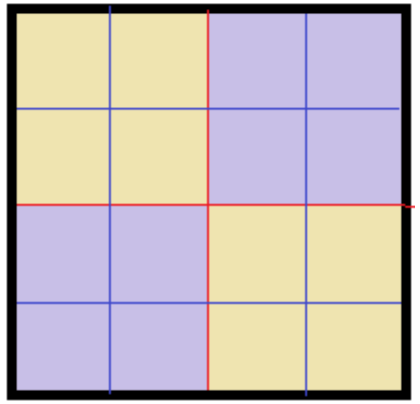
where k is the cancellation exponent.

If a given field changes sign on arbitrarily small scale, it is called **sign singular** (*Sorriso-Valvo+ 2015*).

- k says how much the sign is singular:
- if k=1 the sign of f is strongly singular. This case occurs if f is a Brownian noise
- If k=0 the field f is smooth and the sign is not singular
- **Intermediate cases indicate the presence of smooth fields in random fluctuations**

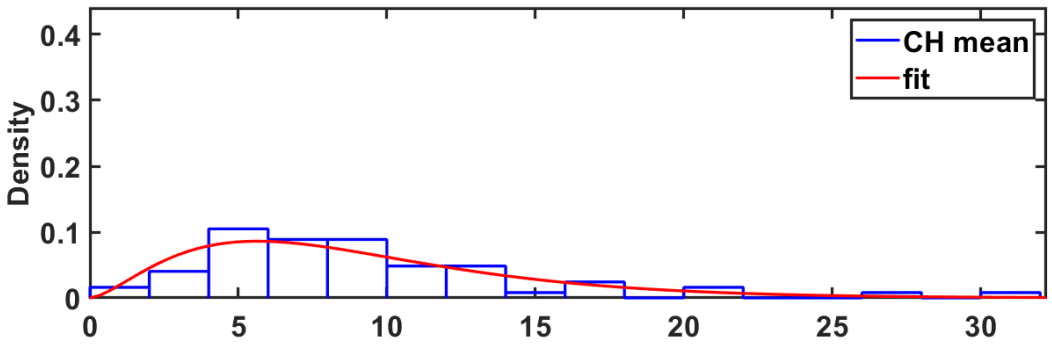


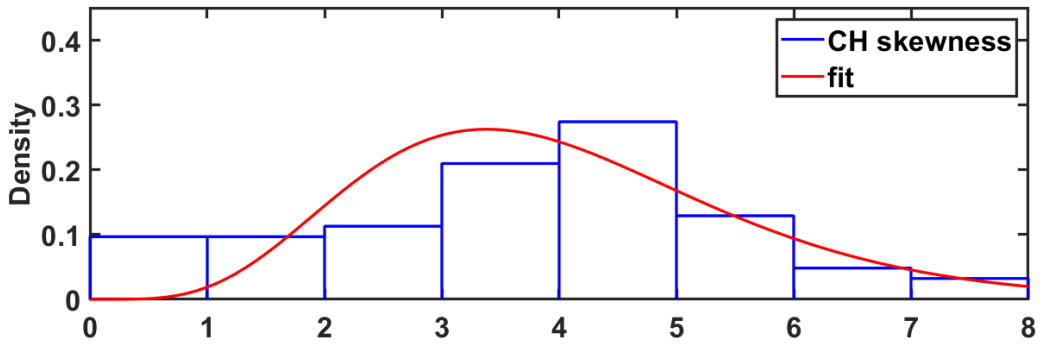
B11	**B12**	**B13**	**B14**
B21	**B22**	**B23**	**B24**
B31	**B32**	**B33**	**B34**
B41	**B42**	**B43**	**B44**

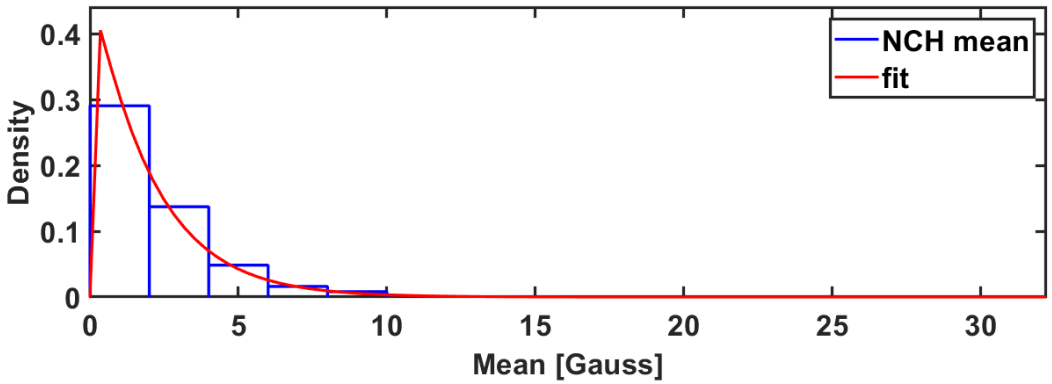


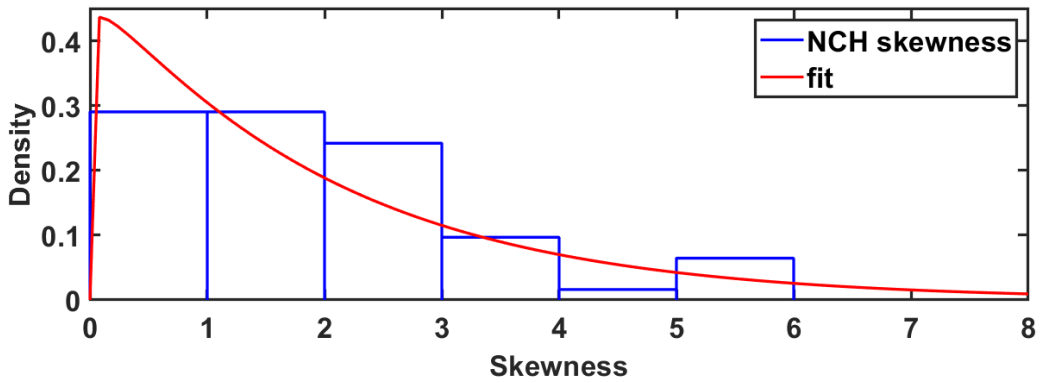
CHs VS NCHs: **Statistics** and Cancellation Functions

The moments (mean and skewness) of the B_{LoS} distributions of the CH and NCH ROIs are reported.





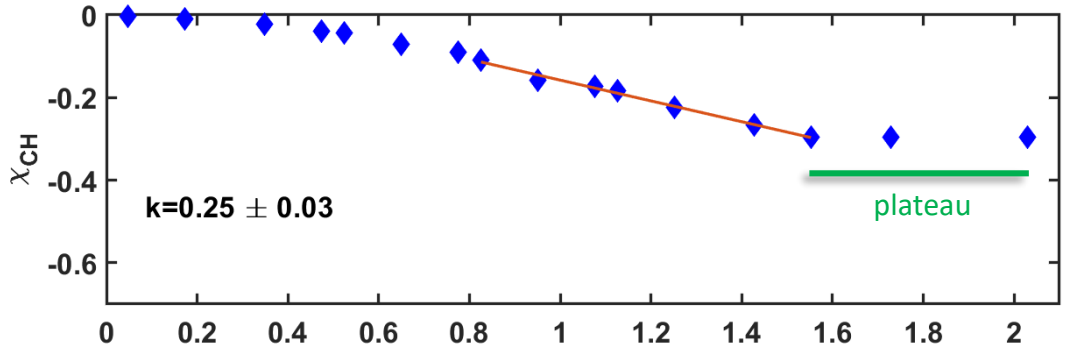


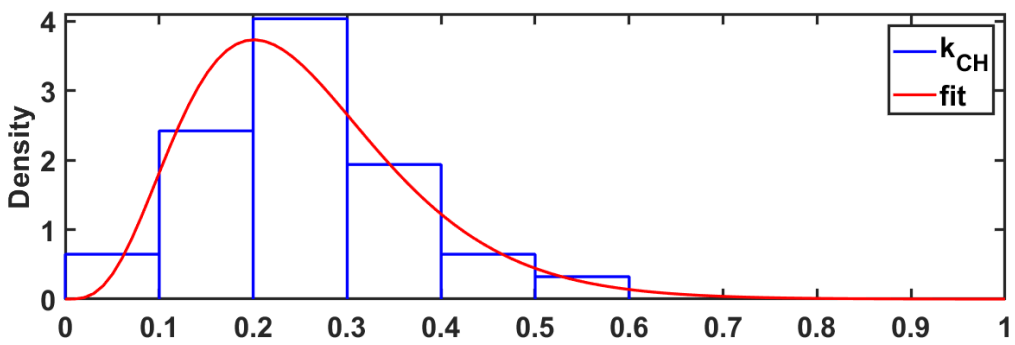


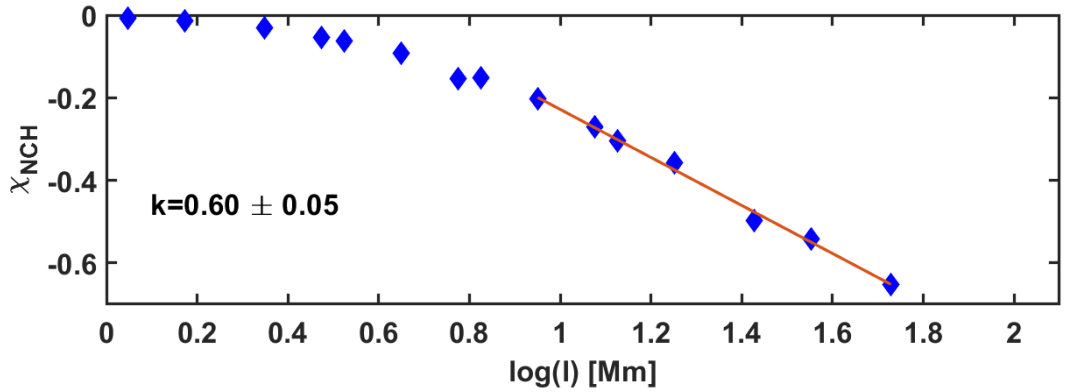
The analysis of the standardized moments for CHs and NCHs shows the imbalance of B_{LoS} in the CHs magnetograms. This behavior is confirmed by the absolute values of the momenta which are higher in the CHs.

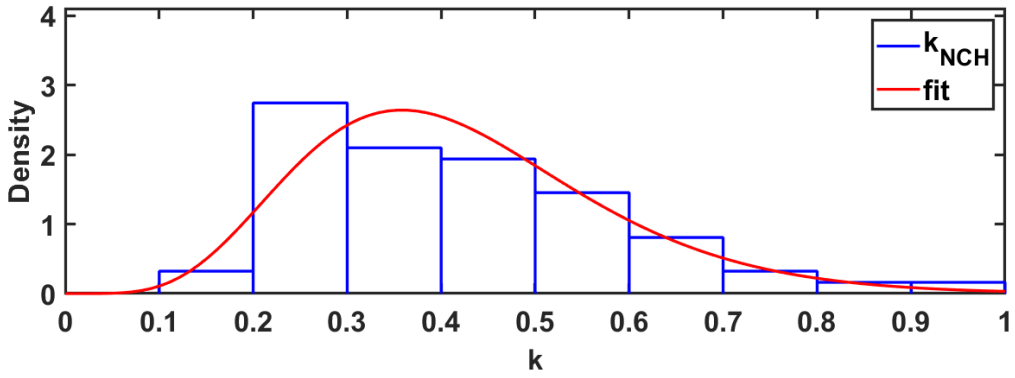
CHs VS NCHs: Statistics and **Cancellation Functions**

The Cancellation Analysis is performed on the samples of 60 CHs and 60 NCHs.









In more than 70% of the magnetograms associated with CHs, a plateau is observed and typically starts at the supergranular scale (30 ±10Mm).

In contrast, less than 20% of the magnetograms associated with NCHs show the presence of a plateau. In this case, the associated typical scale is much greater (50 ± 10 Mm).

Conclusions

In CHs higher cancellation exponent values are less probable

CHs are composed of smooth fields, embedded in a fluctuating background

In more than the 70% of CHs the sign of the magnetic field is no more singular at the supergranular scales

Typically, the unbalance of B_{LoS} in the CHs magnetograms emerges at supergranular scales

Unipolar patches (funnel roots) are rooted in the supergranular networks

Magnetic pattern simulations (not discussed here).

The results of this work are in accordance with the current literature (i.e. Hofmeister et al., 2017)

The analysis of the Cantoresi's Master's thesis work will be reported in a paper in preparation.

Matteo Cantoresi is currently participating in a virtual SOLARNET mobility program with University of Graz dedicated to the "Characterization of the diffusion of magnetic elements inside Coronal Holes".