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Relationship between the coronal green line brightness and magnetic field strength

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Abstract. The quantitative relation between the brightness of the coronal green line 530.5 nm Fe XIV and the magnetic field strength is considered over the 1977-2001 period. It is found that the correlation coefficients between these two parameters calculated separately inside and outside the sunspot formation zone $\pm 30^\circ$ have cyclic variation and occur in anti-phase. This suggests different mechanisms of formation of the corona in the fields of small, medium, and large scales. These results can be used for quantitative verification of the corona heating models.

The relationship between the coronal green line brightness (CGLB) and the magnetic field strength (MFS) has been investigated by constructing the corresponding synoptic maps for the 1977-2001. The CGLB distribution maps are based on the data of patrol observations at a network of the coronal stations, reduced to a uniform photometric system. We use the database compiled by Sýkora 1971, 1992). The magnetic field strength in the corona was calculated under potential approximation from the Wilcox Solar Observatory data, at the height of 1.1 $R_\odot$ approximately corresponding to the coronal green-line observations.

To quantitatively express the degree of agreement between the CGLB and MFS in each pair of the maps, we have calculated the cross-correlation coefficient r for these parameters at the space-coinciding points of the synoptic maps. The coefficient r was calculated for the maps averaged over six consecutive Carrington rotations (CR) at 1-CR steps, as well as for the maps constructed for each individual CR whithout averaging. The correlation coefficient was determined for the entire latitude range of $\pm 70^\circ$, for narrow 10° zones, and, separately, inside the sunspot formation zone of $\pm 30^\circ$ and outside it.

Variations of correlation between the distribution of the magnetic field intensity and CGLB was studied in detail by Badalyan & Obridko 2004. It was found out that the time variation of the correlation coefficient r is different in two latitudinal zones – inside the sunspot formation zone of $\pm 30^\circ$ and outside it. The coefficients r in both these zones display a cyclic behaviour. At the same time, the coefficient r varies in anti-phase in those two zones. In the low-latitude zone, the coefficient r is always positive. It reaches the greatest values at the minimum and decreases significantly to the maximum. Above $\pm 30^\circ$, the coefficient r is sign-variable. It reaches the greatest positive values at the maximum and approximately the same but negative values, at the minimum. The transition of r through zero occurs at the moments of the beginning and the end of the minimum epoch.

Figure 1 illustrates the time variation of the correlation coefficient r in two latitudinal zones. The comparison of two pairs of the curves on each panel shows that: a) the correlation coefficient for the smoothed maps is always higher in absolute value than the coefficient calculated for the non-smoothed maps; b) the correlation curve for the non-smoothed maps is characterized by a greater scattering of the points and is more jagged than the curve for the smoothed maps.

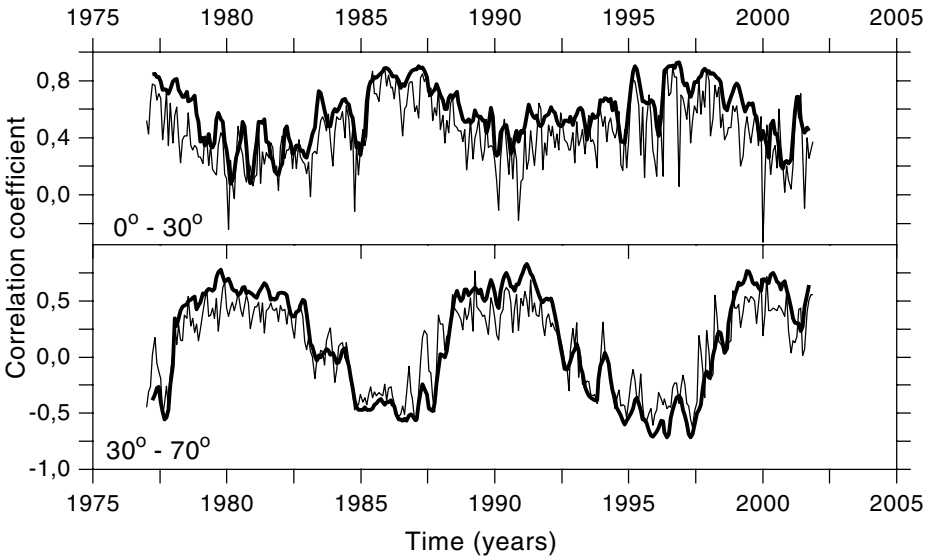

Figure 1. Time variation of the correlation coefficient r the sunspot formation zone of $\pm 30^\circ$ (upper panel) and outside it (lower panel). On both panels, the coefficients r for the maps averaged over six consecutive CR at 1-CR steps are shown by thick lines, and r for the maps plotted for each CR (whithout averaging) are marked by thin lines.

Thus, the maps smoothed over six rotations visualize the long-lived large-scale features in the corona at the height of the green-line observation. The behaviour of r in different latitudinal zones suggests certain conclusions about the effect of the magnetic field on the conditions, under which the green-line emission occurs.

The Fourier analysis of the correlation coefficient revealed the existence of a high-frequency (1–1.5 years) wave in the variation of the coefficient r at all latitudes and showed also a well-defined 5-year wave. It should be noted that the period of 1.3 years has been discovered by helioseismological methods in the magnetic field generation region near the tachocline Howe et al. (2000).

The dependence of the coefficient r on the phase of the cycle implies directly that the fields of different scale have different effect on the coronal brightness. In addition to the cyclic variation, we have also revealed the sign reversal of r at high latitudes. This suggests different mechanisms of formation of the corona in the fields of small, medium, and large scales. The results described above can be used for quantitative verification of different models of the corona heating.

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