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PHOTOSPHERIC FIELD GRADIENT IN THE NEIGHBOURHOOD OF QUIESCENT PROMINENCES

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ABSTRACT

We have determined statistically the horizontal gradiant of the vertical magnetic field in the neighbourhood of filaments inside and outside the active regions during a few months in 1981 and in 1984. The results show that there are meaningful upper and lower limits on the gradiant of the surrounding large scale photospheric magnetic field for the existance of a filament. These limits represent a necessary but not sufficient condition.

INTRODUCTION

Quiescent prominences are known to occur invariably above neutral lines in the magnetograms. However every neutral line does not have an overlying prominence. Thus the presence of a neutral line is a necessary but not sufficient condition of a prominence. Support and stability of a prominence might require the gradiant of the surrounding photospheric field to be within some limits. Here we report the results of our attempt to determine the limits on the vertical component of the large scale photospheric field in the neighbourhood of quiescent prominences.

THE DATA METHOD OF ANALYSIS

For this study we have used the Stanford observatory magnetograms and the nearest-in-time hydrogen-alpha filtergrams from other observatories as published in "Solar Geophysical Data" during September-October 1981 and January-March 1984.

The magnetograms show iso-gauss contours of the line of sight field at ±0.2, ±0.5, ±1.0, ±2.0, ±5.0 G with noise less than 0.1 G and the zero level at less than 0.05 G.

Most of the H-alpha filtergrams are from Sacramento Peak Observatory and some are from Mt.Wilson and other observatories (eg. HAO). On those days on which Solar Geophysical Data does not have any H-alpha filtergram, the nearest-in-time filtergram from Kodaikanal Observatory is used. The time differences between magnetograms and the corresponding filtergrams are between 3 and 5 hours and are taken into account when

identifying the neutral lines associated with the prominence filaments. We have assumed that the prominences seen in H-alpha existed or continued to exist at the time of the corresponding magnetogram. This may not be true in each and every case but it is a reasonable assumption since the chosen prominences were sufficiently long lived and stable. Our second assumption is that the surrounding photospheric field is approximately vertical. This enable us to determine the gradiant of the vertical field according to the formula

$$\frac{dB_r}{ds} = \frac{dB_l}{dl}$$

where B_r and B_l represent respectively the vertical and the line-of-sight components of the photospheric magnetic field ds is an element of horizontal distance and dl is the separation of iso-gauss contours on the magnetograms.

The values of dB_l/dl were determined in the following manner. Photostat copies of the published magnetograms on one-to-one scale were made and used as real magnetograms. Positions of segments of H-alpha filaments were marked on these magnetograms using sunchart grids of the sizes of the filtergrams and the magnetograms, applying position transformation according to the law of solar rotation. The lowest resolvable iso-gauss contours of opposite polarities were identified on the two sides of the filament segments. Short lines were drawn across the filament segment, as nearly perpendicular to the iso-gauss contours on the two sides as possible. The distance dl between the centres of thickness of the iso-gauss contours was measured along the common perpendicular using Abbe's comparator. The iso-gauss levels were also noted. By measuring in 56 cases the separations between the outer edges and the inner edges of the iso-gauss lines it was decided that there was no gain in accuracy in taking the mean of the edge-to-edge measurements. The error in our centre-to-centre measurements was 0.01 mm.

RESULTS

Histograms of the number of points on filaments with respect to the ranges of values of dB_r/ds were plotted separately for filaments inside and outside the active regions during 1981 and 1984. These are shown in figures 1, 2 and 3.

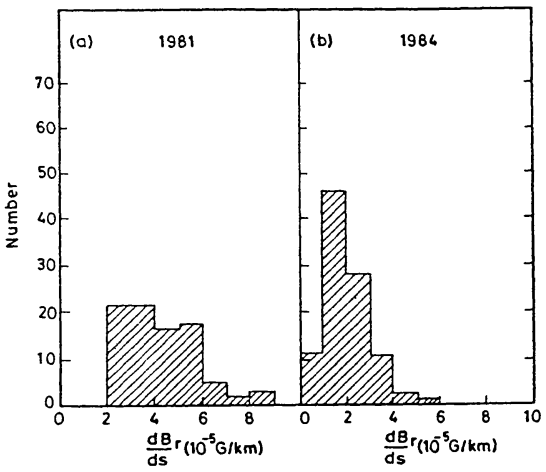

Figure 1. Number of points on filaments having values of dB_r/ds in the given ranges during (a): 1981 and (b):1984.

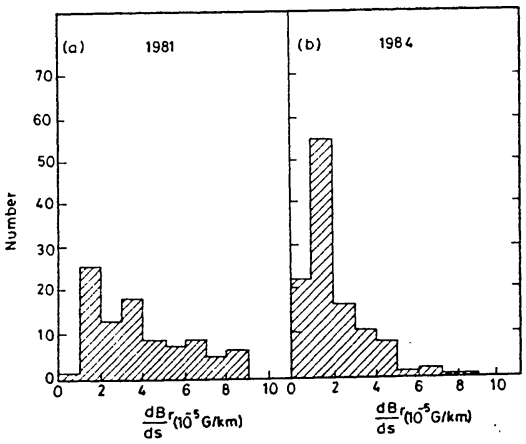

Figure 2. Number of points on neutral lines outside active regionsand without filaments,having values of dB_r/ds in the given ranges during (a): 1981

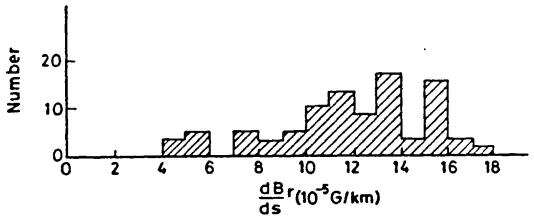

Figure 3. Number of points on filaments within active regions having values of dB_r/ds in the given ranges during 1981.

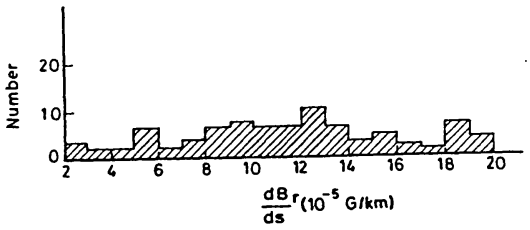

Figure 4. Number of points on neutral lines inside active regions,but without overlying filaments, having values of dB_r/ds in the given ranges.

TABLE I. Mean values and root mean square deviations of dB_r/ds across the filaments

OUTSIDE ACTIVE REGIONS:

1981 : 4.77 ± 1.80 (10^{-5} G/km) (sample size : 96)

1984 : 2.02 ± 0.84 (10^{-5} G/km) (sample size : 293)

IN ACTIVE REGIONS:

1981 : 11.89 ± 4.30 (10^{-5} G/km) (sample size : 59)

TABLE II

Mean values and root mean square deviations of dB_r/ds across neutral lines without filaments were found to be as given below

OUTSIDE ACTIVE REGIONS:

1981 : 4.93 ± 2.52 (10^{-5} G/km) (sample size : 68)

1984 : 1.92 ± 1.13 (10^{-5} G/km) (sample size : 282)

IN ACTIVE REGIONS:

1981 : 13.98 ± 7.10 (10^{-5} G/km) (sample size : 111)

CONCLUSIONS

From the foregoing results we derive the following limits on the values of dB_r/ds inside and outside active regions during 1981 and 1984.

For filaments outside active regions:

In 1981 : lower limit $\approx 2\ 10^{-5}$ G/km ; upper limit $\gtrsim 9\ 10^{-5}$ G/km.

In 1984 : lower limit $< 1\ 10^{-5}$ G/km ; upper limit $\approx 6\ 10^{-5}$ G/km.

For filaments inside active regions:

In 1981 : lower limit $\approx 4\ 10^{-5}$ G/km ; upper limit $\gtrsim 18\ 10^{-5}$ G/km

Comparison with results for neutral lines without filaments (cf. Table II) shows that the above limits are necessary but not sufficient for existence of prominences.

The values of dB_r/ds are smaller during 1984 than during 1981. This may be either due to the difference of the phase of the sunspot cycle or due to the fact that the sensitivity of the Standard magnetograms changed from 0.5 G in 1981 to 0.2 G in 1984. Similar studies by maximov and Ermakova (1987) had yielded a mean value of dB_r/ds ≈ 0.0072 G/km for filaments inside active regions and a mean gradiant ≈ 0.0202 G/km across neutral lines without filaments. The stronger values obtained by them refers to the small-scale magnetograms used by them (as indicated by their iso-gauss contours viz.30, 60, 90 G). The smallness of the root mean square deviations with respect to the mean values in our results shows that there exist meaningful limits on the field gradiant even in the large scale pattern of the magnetic field in the neighbourhood of the filaments.

REFERENCES

Maximov,V.P. and Ermakova,L.V., 1987, Sov. Astron. 31, 438.

GRADIJENT FOTOSFERSKOG MAGNETSKOG POLJA U OKOLINI MIRNIH PROMINENCIJA

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Izlaganje

Sažetak: Statistički je određen horizontalni gradijent vertikalnog magnetskog polja u okolini filamenta koji su se nalazili unutar i izvan aktivnih područja za period od nekoliko mjeseci u 1981. i 1984. godini. Rezultati pokazuju da postoje prihvatljive gornje i donje granice iznosa gradijenta fotosferskog polja velikih razmera koje okružuje filament za mogućnost njegovog opstanka. Te granice predstavljaju nužan, ali ne i dovoljan uvjet.