Size of the Ca^+ Coarse Network in the Solar Chromosphere at Sunspot Minimum

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ABSTRACT

Auto-correlation measures of the coarse Ca^+ network made on selected spectroheliograms obtained during the solar minimum period of 1964 and 1965 are described. The full width at half maximum of the normalised A.C. curve gives a mean value of $(31.37 \pm 0.4) \times 10^3$ km for the size of the network. The relationship between these network cells and those of the supergranulation are discussed.

A characteristic feature of Ca^+ spectroheliograms is the prevalence all over the solar disc of a bright polygonal network. At sunspot minimum when solar activity is low and the active regions almost non-existent, a well exposed K_{232} spectroheliogram shows the bright network with associated fine mottling. The calcium excitation is known to be the seat of magnetic fields distributed on the solar surface. An almost one-to-one correlation exists between the spatial pattern of longitudinal magnetic field and the Ca^+ network.

The recent discovery by (LEIGHTON, NOYES and SIMON 1962) of a second convective circulatory field on the sun which is now known as the "supergranulation" and of its close relationship with the chromospheric network brings fresh interest to the problem of the formation of the network and the mechanism by which the boundaries of cells concentrate the magnetic fields. Leighton, (SIMON and LEIGHTON, 1964) has developed a theory, whereby the cellular motions concentrate, the very weak magnetic fields distributed over a large area, into narrow configurations along the boundaries of these convection cells. The chromospheric network, magnetic fields and the supergranulation at the lower levels in the photosphere, thus, all seem to be linked together.

An important property of the Ca^+ network is its size. An examination of a spectroheliogram indicates that the polygonal network is by no means of uniform size. ROGERSON (1955) has indicated a spread in size from 25000 to 70000 kms. An additional difficulty comes about by the fact that the polygons are usually fragmentary. Despite these irregularities in size and shape and a lack of completeness of the polygon sides, we see a striking size characteristic and a periodicity in the cell spacing.

Our principal aim has been to derive a mean cell size of the Ca^+ network, by correlation techniques, which would be representative of the minimum phase of the solar cycle. If $I(r', t')$ indicates the intensity fluctuation over the average brightness at one position and instant and $I(r'', t'')$ the fluctuation at another place and time, the two dimensional autocorrelation function may be defined as

$$A(r,t) \equiv K \left\langle I(r',t') \; I(r'', t'') \right\rangle$$

where $\qquad r = |r' - r''|, \quad t = |t' - t''| .$

We are interested in only the spatial correlation $A(r,o)$ and we proceed to measure this quantity on the assumption that the measurements made are a function of displacement and not of direction.

The K_{232} spectroheliograms obtained at Kodaikanal have a solar image diameter of 60 mm or an image scale of 32"/mm. This corresponds to a distance of 23,250 km of solar surface per millimeter on the image. The plates chosen were obtained in January, February and June of 1964 and January of 1965, and were free of dust marks and photographic flaws, especially at the centre of the solar disc. A region 12.5 mm x 12.5 mm on the plate was enlarged 2C fold by means of a Zeiss spectrum projector, and a non-glossy print obtained. For a correlation measurement the marked-out region is projected onto the print of the same negative and one gets a minimum of scattered light at perfect super position. This corresponds to the high correlation position. When the negative is displaced slightly by moving the plate stage, the scattered light increases and the correlation decreases. The scattered light is measured by a photomultiplier, the amplified output of which feeds a Brown Recorder. The negative is displaced in known intervals and the corresponding scattered light amounts determined. The normalized auto-correlation curve can thus be determined from the scattered light deflections. The full width at half maximum of the auto-correlation function converted into kilometers on the solar surface yields a measure of the average linear size of the network cells.

The spectroheliograms with both the network and the fine mottling gave linear sizes in the range 6000 to 10000 kms. This is due to the predominance of the fine mottles of diameter 2-3 seconds of arc. To study the coarse network we have, therefore, selected plates that were too lightly exposed for the fine mottling to be present or those which were taken in average "seeing" so as to be free of the fine mottling within the network cells.

The sizes of the network cells determined by us have a very limited range. The mean value obtained is $(31.37 \pm 0.4) \times 10^3$ kms. We can compare this with a value of $(29.8 \pm 1.1) \times 10^3$ kms obtained by Leighton (SIMON and LEIGHTON, 1964) from spectroheliograms obtained in 1961, and a size range of 25000 to 75000 km derived by Rogerson.

An obvious inference from this study, is the need to minimize in such measures the contribution of the fine mottling. While the size range is low when such a precautionary measure is adopted, it is perhaps large enough to prevent an exact evaluation that might portray changes in cell characteristics at different phases of the solar cycle.

REFERENCES

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