MORPHOLOGICAL AND DYNAMICAL PROPERTIES OF MAGNETIC BRIGHT POINTS IN THE QUIET PHOTOSPHERE.

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Introduction.

Observations in photospheric lines reveal that many small bright points are present on the quiet surface of the sun, at the photospheric level. They have a tendency to concentrate at the vertices of several supergranular cells (fig.1), but a few points are present, in the cells'interior. In active regions the large concentration of bright points gives the well known filigree aspect (fig.2).

It has been shown that strong magnetic fields, concentrated in small tubes, are associated to the photospheric bright points. These elementary magnetic fields seem to take a proeminent part in a number of solar phenomena.

Observations

The dimension of the photospheric bright points is at the limit of resolution of the best ground based instruments. For this reason, though they were discovered, at Sacramento Peak Observatory in the early seventies, their morphological and dynamical properties are still very poorly known. Their knowledge is, however, essential if we want to be able to understand, on the one hand, the magnetic field concentration phenomenon, and, on the other hand, solar features like filigree, faculæ , sunspots, spicules, which result from the interaction of magnetic field with convection. Magnetic, bright points, perhaps take a proeminent part in the production of flares,too.

With the 50 cm refractor of the Pic du Midi Observatory, I recently obtained the first time series - one hour long - which permits the study of the evolution of photospheric bright points. The observations consist in photographs taken quasi-simultaneously in the K line of ionized calcium, where the points appear bright, and in the continuum. (For instrumental reasons I now use a 10 Å broad filter centered at 4308; near this wavelength many iron lines are present). The photographs are spaced by about thirty seconds and the spatial resolution was sufficiently high (that is 0.3" or better) during about one hour.

Statistical properties

Photospheric bright points are distributed over all the quiet surface of the sun (fig. 3) :

- in the form of single points in 33 percent of cases
- in the form of pairs in 32 per cent of cases (I call a pair an association of two points separated by less than 1"5).
- in the form of concentrations of three points or more in 35 per cent of cases.

There are about 2 points in a square of 10 arc sec.

The figure 4 is a histogram of measured dimensions of photospheric bright points. It shows that 82 % of points are of observed dimensions smaller than 0.5" and that 95 % of them are of dimensions smaller than 1".

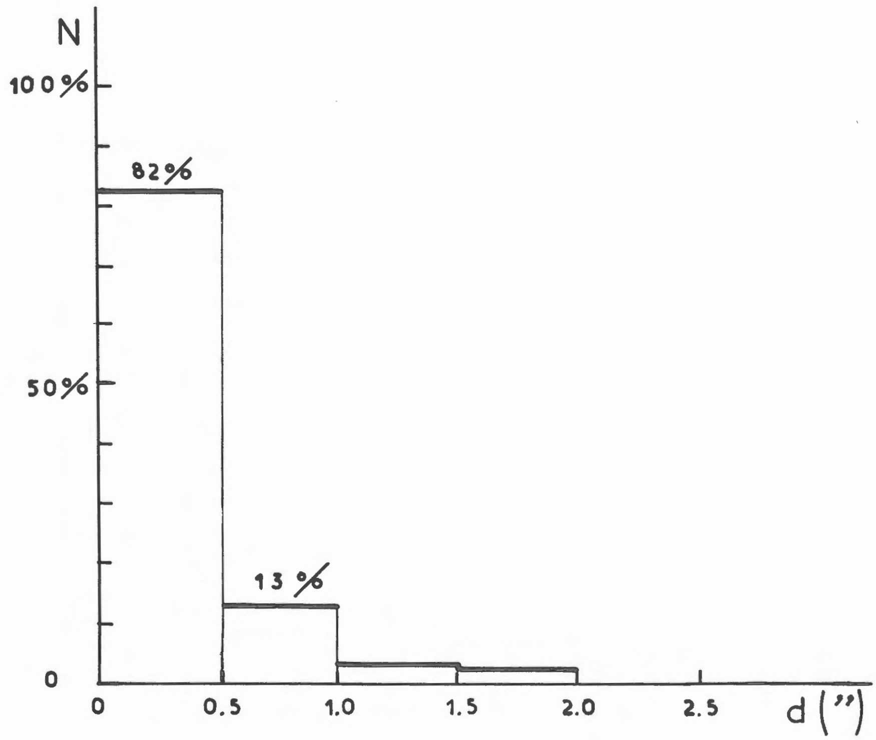

Figure 4.

Histogram of measured dimensions of photospheric bright points.

Bright points dynamical behaviour

As a first step of a more extended work I am studying the behaviour of single bright points in quiet regions. The results presented here are not of great statistical significance because at the moment I have studied the evolution of a few points only. Nevertheless they already clearly show the dynamical behaviour of bright points in quiet regions.

Bright points do not appear anywhere with respect to the granular network, but at the vertices of several granules (never in granules nor in spaces between two granules only).

The lifetime ranges from 12 or 35 min.,and has a mean value of 25 min. (it is not as short as a few min. as estimated previously).

In the K line the points appear bright for a few minutes only, ten minutes at most.

After the brightening the points fade away slowly in intergranular spaces.

Four out of the eleven bright points studied have a remarkable behavior : they first grow longer, become unusually bright in the K line and separate in two fragments. After the separation both points evolve independently. A careful examination of the separation process gives the impression that the points really split. But at that time I cannot reject another possibility : the appearance of a new point very close from the first one.

It appears that the pairs of points result either from the fragmentation of one element, or from the appearance of a new point near an old one. Each element of a pair evolves independently from the other.

Physical consequences

The results presented here show that the bright points and then the associated magnetic tubes, appear in the photosphere in regions of strong downdrafts that probably the vertices of several granules are. The relatively short lifetime and the tendency to split, if confirmed, show that they are rather unstable features. We can already mention some possible implications of these new results :

Downdrafts favour the appearance and concentration of photospheric magnetic fields. This confirms previous observational and theoretical results. At the vertices of several granules a helical downdraft take perhaps place and may generate a magnetic field like in the "battery process" described by W. Unno in his communication.

Recent theories of formation and decay of sunspots are based on a strong stability of magnetic tubes; this does not seem to be the case.

The concentration of bright points at the vertices of supergranules is usually explained by an outward migration of magnetic tubes, emerged in cells interior, due to horizontal convective flow. But this process requires long lived features. Our results suggest another explanation : vertices of supergranules simply are regions of strong drawndrafts (where supergranular downdraft is added to granular downdraft) propicious to the appearance of photospheric bright points.

The lifetime of the bright phase of a photospheric point is about 5 min. This is just the lifetime of spicules. This may suggest, like Shibata has proposed in his communication, that spicules are constructed by the appearance of a photospheric bright point.

The results presented here are deduced from a study of single bright points in the quiet photosphere. This study is the first step of a more extended work which will include the study of bright points in active regions and at various positions between the center of the disk and the limb. Required observations are already available. It appears also from these results that it will be very important, for the understanding of the appearance and the concentration of photospheric magnetic field, to measure downward velocity at the vertices of several granules and to compare it to the velocity in intergranular spaces, both in the interior and at the vertices of supergranular cells.

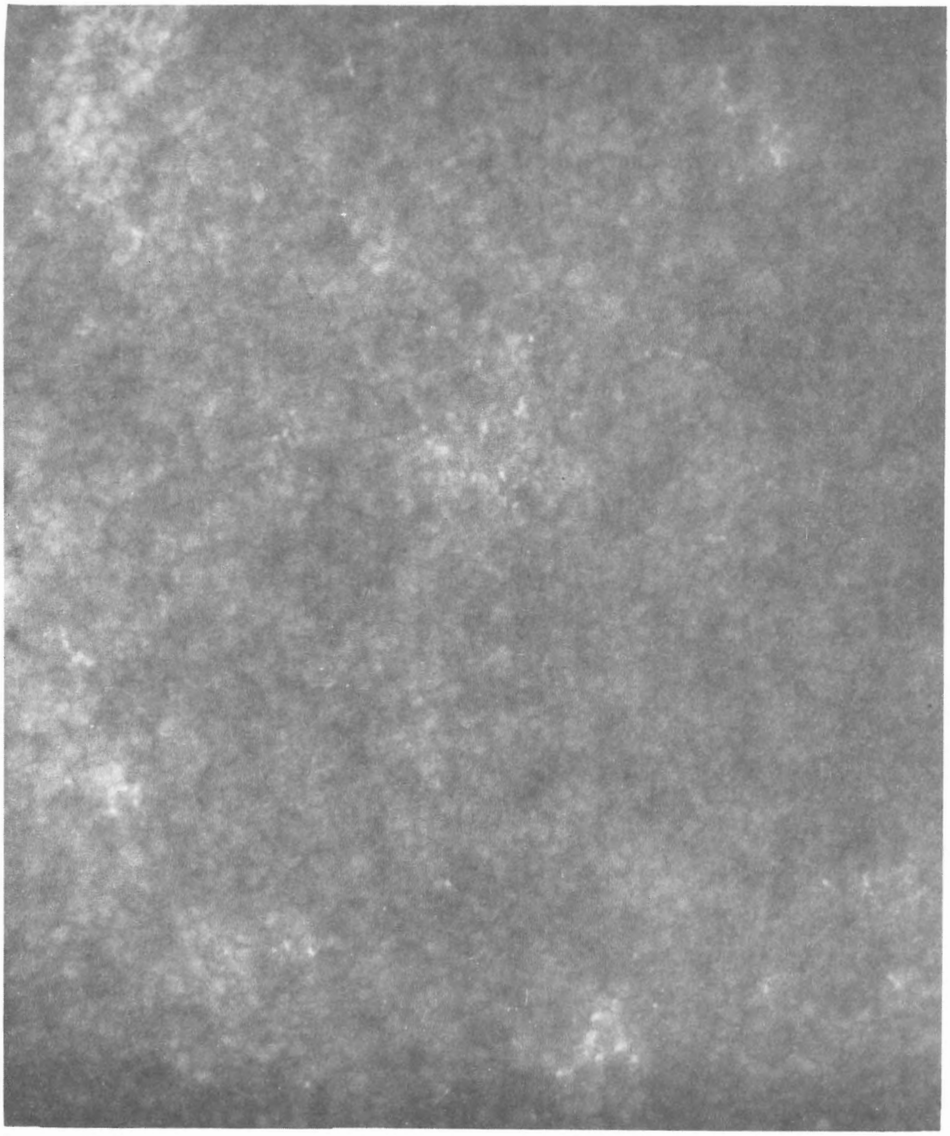

Figure 1. Bright points in the quiet photosphere visible through a 13 Å wide filter centered on the Ca II K 3933 Å line. They outline the supergranular cells. July, 19, 1975. 1 mm = 0"7

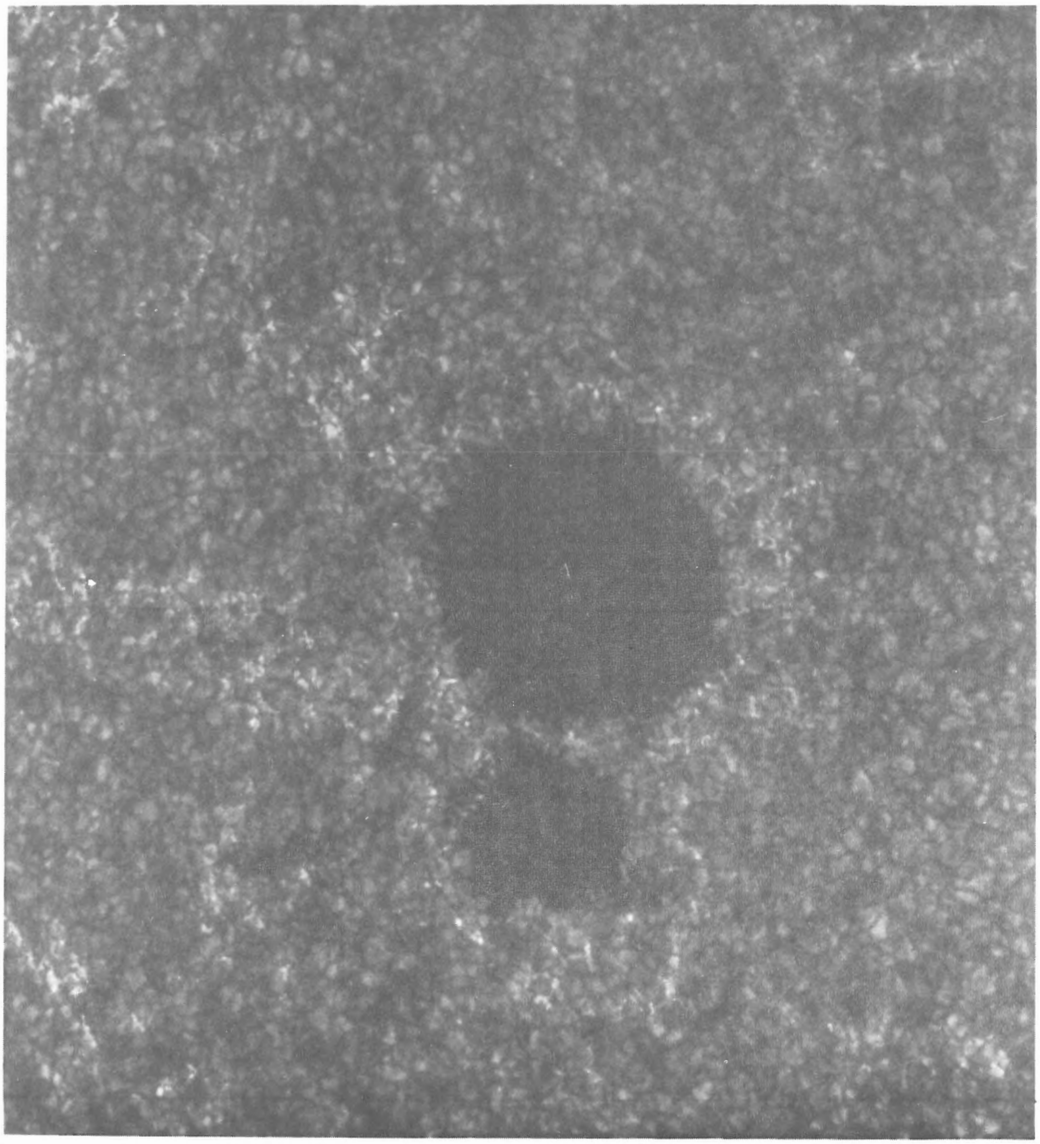

Figure 2. Bright points around a sunspot visible through a 10 Å wide filter centered at 4308 Å. June, 3, 1980. 1 mm = 0"7.

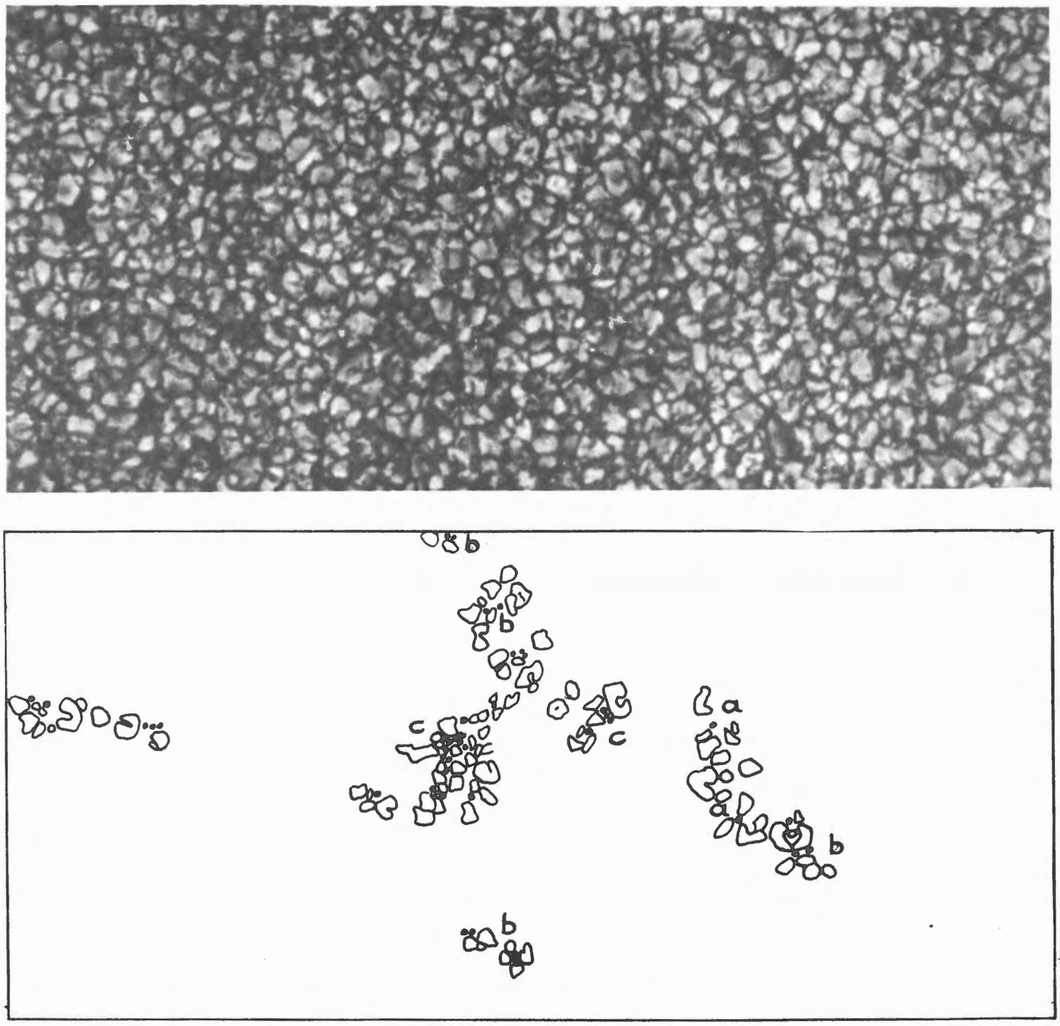

Figure 3. Bright points as visible in the continuum. a : single point; b : pairs of points; c : groups of points. June, 9, 1978. 1 mm = 0"65.