The Bright Points in the Ca II K-Line and Their Relation to the Inner Network Magnetic Structures

K.R.Sivaraman
Indian Institute of Astrophysics
Bangalore - 560034 India

Abstract. We present observational evidence to show that the K_{2V} points bear a one to one correspondence with the inner network magnetic elements when the quiet sun is viewed under good spatial resolution. This would have implications on the theories of chromospheric heating over quiet regions on the sun.

1.Introduction

With the revival of the hope of establishing long period acoustic waves as a candidate agency for the heating of the quiet solar chromosphere, the interest in the finest structures in the chromosphere that can support these waves and also act as guides to channelise them has brightened up. The quiet chromosphere seen in the Ca II K line spectroheliograms shows three distinct structures: the network which is cospatial with the supergranulation cells, the bright points that populate the interior of the network and finally the truely quiet (unresolved) chromosphere present in between the bright points. It is known that the excess Ca II K emission bears a one to one corespondence with the magnetic field regions and the emission is a good indicator of magnetically stimulated (non thermal) heating. This was demonstrated for the plages and the network by Leighton and his coworkers (1962). The bright points also referred to as cell points or K_{2V} points or K_{2V} grains in the literature gained considerable attention when their properties (sizes, life times, line profiles, K_2 emission widths, K_{2V}/K_{2R} ratios, etc) were uncovered through the investigations of Bappu and Sivaraman (1971) and Liu (1974). The observational evidence for the upward propagation of energy in the chromosphere was provided through the investigations of Liu (1974) and Punetha (1974). The detailed study of a long time sequence spectra in the H-line (Cram and Dame 1983, Sivaraman 1980 unpublished) confirmed the earlier findings that the bright points (henceforth referred to as BPs) act as conduits for the propagation of energy to the chromospheric level from below. According to Cram and Dame (1983) since the observed radiation loss from the cell points is of the same order as the theoretical radiation loss from the quiet chromosphere, the cell points themselves are the sites of a significant fraction of the mechanical energy dissipation responsible for the heating of the quiet, inner-network chromosphere. Kalkofen (1989a, 1989b) has brought together all the facts known so far (both observational and theoretical) and showed that the inner network BPs are the sites where major chromospheric heating takes place and that the heating is by long period acoustic waves. These BPs have magnetic fields associated with them and so can be considered as flux tubes. Appearance of waves in them suggests that this field is able to channelise and contain these waves. The chromospheric brightenings in the BPs and their association with the magnetic field would also imply that the role of the electrodynamic process in the non-radiative heating mechanisms will have to be examined and understood well. It is in this context that the results of our observations (Sivaraman and Livingston 1982) have attracted the attention.

2. Observations and reduction of data

I shall describe the way the observations were collected and the data were analysed by us. We obtained the observations at the Vacuum Tower Telescope of the KPNO during 2 spells of observing, one in May 1980 and the other in March 1981. We obtained the magnetic scans in Fe I 8688A over a quiet region of area 256 x 512 arc sec. around the centre of the disc using the 512 channel magnetograph. The observations of May 9, 1980 consisted of a series of 21 brightness scans (B_3 to B_{23}) in Ca II K_{232} with a pass band of 1.1 A repeated at every 180 seconds. These 21 scans were sandwitched between two magnetic scans at the start (M_1 and M_2) and two scans at the end (M_{24} and M_{25}) all scans being over the same area (256x512sec) on the sun. The 25 scans thus acquired were labelled thus:

$$M_1, M_2, B_3 \ldots B_{23}, M_{24}, M_{25}$$

These 25 scans stored in tapes were transferred to the cyber computer and were then accessed for viewing via the Interactive Picture Processing System (IPPS) on the COMTAL display unit. The COMTAL system has three channels and any three files can be called upon and displayed on the screen in succession or blinked for detailed visual examination. Scan M_1 was blinked with each of the brightness scans from B_3......B_{23} in succession. Visual results from blinking were tablulated as coincidences and non coincidences. The field strengh estimates were also noted down. In the observing run on March 1981,we obtained the magnetic scans at the Vacuum telescope simultaneous with the K_2V spectroheliograms at the Mc Math East wing auxiliary facility. Photographic prints of these were then prepared and coaligned for identification of coincidences.

3. Results

From an examination of a large sample of K_{2V} points we find that, there is a strong evidence to show that the BPs in the interior of the network bear a one to one correspondence with the magnetic elements. In the sample we examined there was no instance where a BP was not associated with a magnetic element although there were instances of magnetic points not associated with bright points. This can be understood in terms of the finite life time of the BPs which is the time span of the light curve of a BP (100-200 sec). The analysis showed that a new BP is born in the same location of a previous BP, this being the location of a magnetic point and the BPs have no preference for either polarity i.e. the BPs are observed to be associated with either a positive or negative polarity with equal probability. The measurement of magnetic fields of over 500 elements shows that the most common values of the field lie in the range 10-20 G as observed with our seeing limited resolution (Fig.1). There are however a few elements associated with higher field strengths, the maximum value from our sample was around 70-80 G. Another interesting finding is that the brightening appears to be more in those BPs associated with fields $>$ 20 G, whereas the BPs associated with field strengths $<$ 10 G tend to be weaker even at their peak brightness phase and those in regions of $\leq$ 5 G were marginially identifiable. The presence of the magnetic field thus seems to be an essential precondition which decides the location of the BP within the network. Theoretical investigations trying to explain the chromospheric heating using waves in the flux tubes would find our results useful and very supportive. In view of the importance of these results we suggest that these observations be repeated and our results confirmed. Our observations are seeing limited and it would be worth while if similar observations may be conducted with newer facilities in the Canary Islands under better viewing conditions.

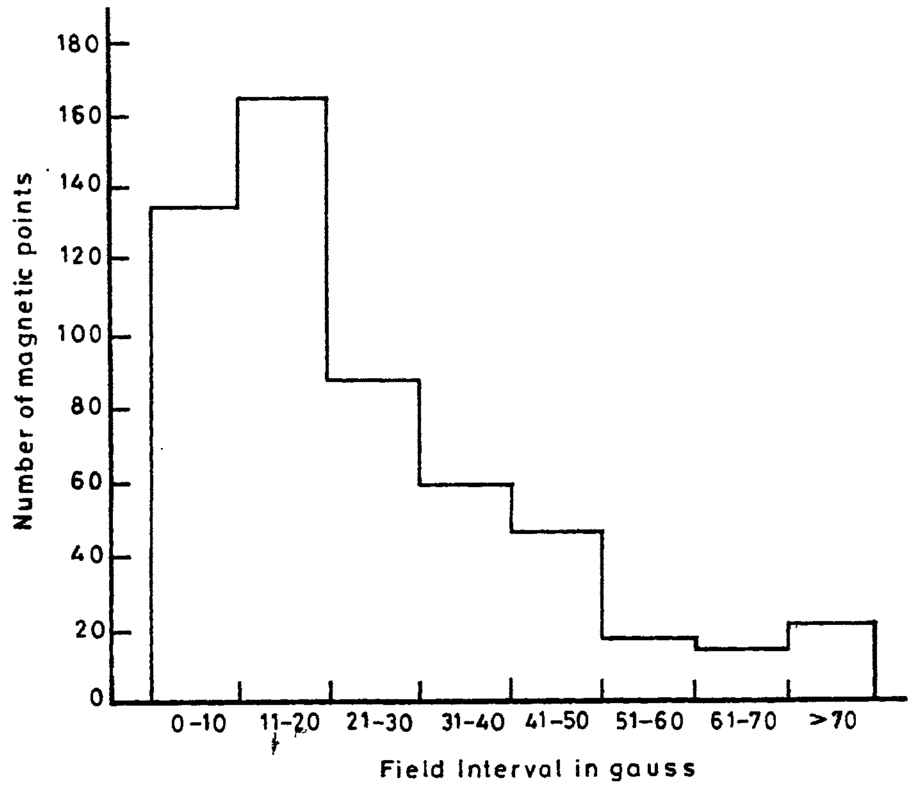

Figure 1. Distribution of magnetic field in magnetic points associated with BPs

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Discussion

Koutchmy: The magnetic fields you are talking about are intra-network magnetic fields so they should correspond to ephemeral regions. Is it correct?

Answer: We made an attempt to relate the two; the relationship is not clear.

Ryutova: I'd like to ask Dr.Sivaraman and previous speaker Dr.Habbal what are the life-times of B.Ps in chromospheric and in coronal regions (coronal holes and active regions.

Answer: The life times of the chromospheric bright points are in the range of 100-200 sec typical value would be around 3 minutes.

Sterling: What is the period of recurrence for the bright point?

Answer: The bright points pass through one full brightness cycle (light curve) in about 3 minutes. This is referred to as the life time of a bright point. Typically three such brightness cycles, one following the other is common, although there are occasions when even 6 or 9 cycles have been observed by Liu (1974).