Ca II K_{2V} SPECTRAL FEATURES AND THEIR RELATION TO SMALL-SCALE PHOTOSPHERIC MAGNETIC FIELDS*

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Abstract. Although the Ca II K_{232} network is known to be cospatial with magnetic elements there has been doubt as to the magnetic origin of the fainter K_{2V} points. We demonstrate that weak magnetic elements also lie at the roots of the K_{2V} points, and because the latter are numerous they may contribute sensibly to the integrated light profile of Ca II K.

1. Introduction

It has been well established that chromospheric plage and the active, or bright, network, as shown on Ca II K_{232} spectroheliograms, are cospatial with photospheric magnetic fields (e.g. see Frazier, 1970). What has remained an open question is whether or not the K_{2V} bright points associated with the fainter network fragments, or even interior to the network, are similarly cospatial with magnetic features. These lesser K_{2V} bright points appear to be transitory having life times of a little more than 100 s (Liu *et al.*, 1972). Yet taken over the entire disk the lesser bright points add up and contribute significantly to the integrated light Ca II K profile (Bappu and Sivaraman, 1971; Lean *et al.*, 1981). Stated another way, are all K_{2V} emission features tied to magnetic fields or are there field-free exciting mechanisms that cause chromospheric heating? To answer these questions requires observations of both high sensitivity and good seeing. These conditions have now been achieved, at least to a limited degree, and we report herein that magnetism appears to be a necessary progenitor of the K_{2V} emission.

2. Observations

The observations were obtained at the vacuum tower telescope of the Kitt Peak National Observatory in May 1980 and in March 1981. The 512 channel magnetograph (Livingston *et al.*, 1976) was operated in its standard area scan configuration. In this mode it records brightness (B), velocity (V), and magnetic field (M) simultaneously along a line of 512 arc sec square pixels. The magnetic scans were taken in the line Fe I

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8688 Å over a quiet region near disc centre and covering an area of 256 × 512 arc sec. The spectral bandpass for the Ca II scans was 1.1 Å which spans the K_{232} spectral feature. The scheme of the observations on May 9, 1980 was first to take two magnetic scans in Fe I 8688, and then in rapid succession a series of Ca II K_{232} brightness scans, followed at the end by a final two magnetic scans. The repetition rate for the K_{232} brightness scans was 180 s for a total of 21 frames. A somewhat better procedure might have been to alternate the K_{232} and Fe 8688 scans, but the time wasted for this instrumental changeover was deemed excessive. Since we know that the life times of even the weak inner network fields exceeds one hour (Harvey, 1977), the adopted schedule was adequate to study the association of the two classes of structure.

The observations of March 9 and 10, 1981, followed a different plan. Magnetic scans were taken at the vacuum telescope at the same time that K_{2V} photographic spectroheliograms were acquired with the McMath East Auxiliary. On this occasion the repetition rate was 5 min.

3. Reduction of Observations and Results

Although all the data acquired above have been used for this work, the data of May 9 have merited a detailed study, the seeing being best on that day. All 25 scans are stored as files on magnetic tape. This data was transferred to the Cyber computer and then accessed for viewing via the Interactive Picture Processing System (IPPS). The final picture was displayed on the TV screen of a COMTAL display unit. The COMTAL system has three channels and any three files on the tape can be called up and displayed on the screen in succession or blinked for detailed examination.

The first file, containing magnetic scans M1 and M2, was blinked with later magnetic scans M24 and M25 to verify the reality of the weaker magnetic features. M1 was then blinked in turn with the succession of K_{232} spectroheliograms B3 through B23. The brightness scan B4 shows the bright points nicely and the pair M1 and B4 are reproduced in Figure 1. Visual results from blinking were tabulated as coincidences and non-coincidences, plus estimates of field strength.

In the case of the observations of March 1981, the magnetic scans were photographed on the COMTAL screen and these pictures were compared with the photographic prints of the corresponding spectroheliograms.

From the large sample of hundreds of bright points examined, we find that there is an unmistakable evidence to show that the bright points located in the interior of the network have a one to one correspondence with the magnetic elements. The bright points and the magnetic elements can be identified in their respective scans without ambiguity.

The brightness scans of May 9 last for nearly one hour with a repetition time of 180 s. While examining the files, the life time aspect of the bright points was apparent in the following way. The bright points are present only on the same locations as the magnetic points inside the network. In many instances magnetic points are seen which do not have bright points associated with them. This can be understood in terms of the finite life time

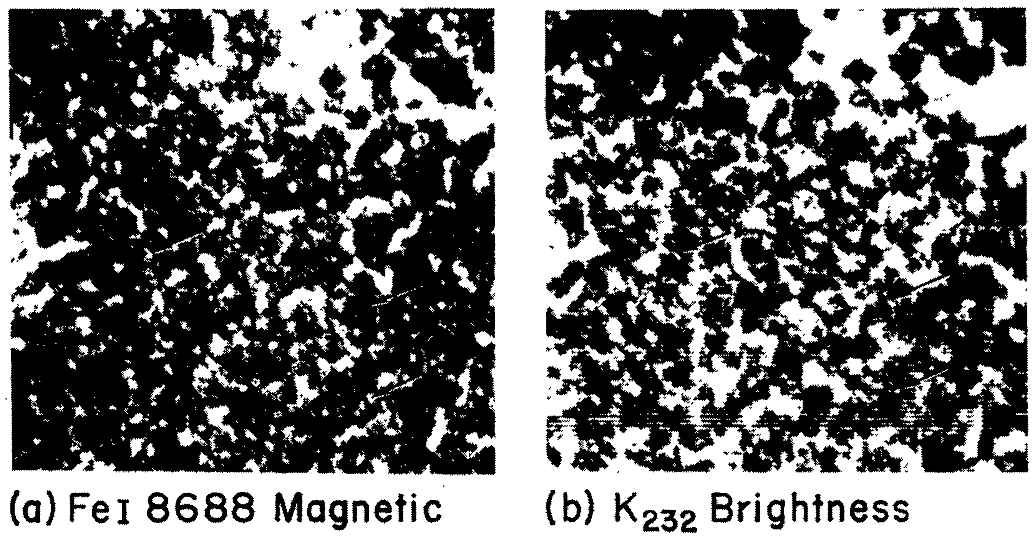

Fig. 1. (a) Magnetogram in Fe I 8688 Å. (b) K_{232} spectroheliogram. Part of two frames from the sequence of magnetogram and spectroheliogram of May 9, 1980 near the disk centre. The pair illustrates a number of cases of bright points and their one to one association with magnetic points of either polarity.

of the bright points. A new bright point is born in the same region where its predecessor was also located, this region being the location of a magnetic element. No instance was found where a bright point was not associated with a magnetic element. The magnetic scans M1 and M2 look almost identical and all the magnetic features covered in the field can be seen to be present in about the same locations, while in M24 and M25, some of them have shifted slightly to new locations. This migration has been confirmed by a more detailed examination of the photographic prints of these files using the long lived and well defined network features as reference points. On such occasions, the bright points could be picked up in the new locations of the magnetic elements.

From the large sample of bright points examined for correspondence with the magnetic elements we find that the bright points have no preference for either polarity. The bright points are observed to be associated with either a positive or negative polarity magnetic elements with equal probability. The fields of some 500 magnetic elements were measured with the help of the magnetograph calibration. The distribution of magnetic field strength is shown in Figure 2. The field strength is seen to be clustered in the 10–20 G range when observed with our seeing limited resolution. There are a few bright points associated with higher field strengths, the maximum value from our sample being around 70–80 G. Another noteworthy aspect is that in those locations where the average field is greater than 20 G, there is a better chance of the bright point attaining a high level of brightness during its life time. In other words, if a bright point with a high level of peak brightness is picked up in the brightness scan, the magnetic element associated with it is seen to have an apparent field strength of more than 20 G. Also

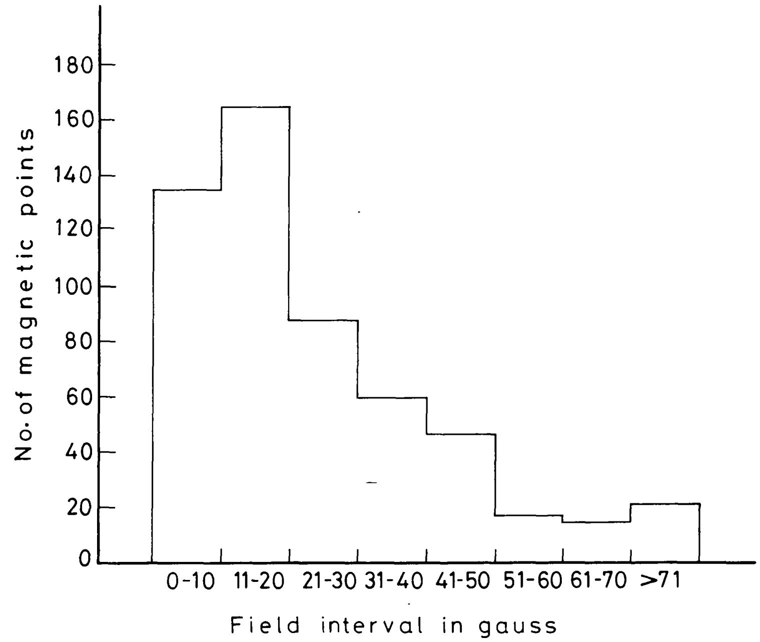

Fig. 2. Distribution of magnetic field associated with the magnetic points.

we find that when the strength of the field is lower than 10 G the bright points in these locations tend to be weak even at peak brightness. They never attain in their whole life span a brightness level as much as those prevailing in strong field regions. For fields of the order of 5 G or less the bright points are marginally identified against the background. All these deductions probably follow from our limited spatial resolution.

4. Discussion

It is now clear that there is a one to one correspondence between bright points and the discrete magnetic structures in the interior of the network. This together with the observation that a bright point shifts to occupy the new location of its associated magnetic point (perhaps displaced by horizontal flows) and so maintains a one to one correlation, leads to the conclusion that the presence of the magnetic field seems to be an essential precondition which decides the location of the bright point within the network. If these bright points represent regions of upward propagation of energy (Liu, 1974) it seems logical to infer that this energy propagation is guided by the magnetic fields in the magnetic structure associated with the bright point.

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