Ca II K BRIGHT POINTS AND THE SOLAR CYCLE

(Research Note)

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Abstract. We have made number counts of the bright points that populate the interior of the Ca II network in the solar chromosphere for four solar cycles. We find that the number of these fine structures during the solar maximum exceeds that during the minimum phase on an average by 30%. The contribution due to this excess number would need to be taken into account while explaining the variation in the Ca II K emission profiles of the integrated sunlight from the solar minimum to the maximum.

1. Introduction

During the past decade there have been concentrated efforts to understand the spatial and temporal behaviour of the finest structures in the solar chromosphere seen in the Ca II K or H line and their role in providing answers to some of the vital problems concerning the chromosphere of the Sun and hence of Sun-like stars. A K_{232} spectroheliogram obtained under good seeing shows a striking predominance of these finest structures that populate the interior of the network. Bappu and Sivaraman (1971) have examined the K-line profiles of a large number of these fine structures termed by them as the bright points. Their important finding, besides the size and life times of these structures, is that the emission profile of a bright point is similar to the integrated spectrum of the Sun in the K-line and both the profiles have identical half power widths. This holds true especially in the case of the quiet Sun. This aspect that the widths are identical, makes the bright point a fundamental entity of the solar chromosphere and also leads to the conclusion that these entities are the ones that, operating cumulatively provide the width exhibited by the quiet Sun when viewed as a star. The importance of their role is further enhanced by the observational result that these show periodic intensity enhancements which are construed as the manifestations of the upward propagation of the disturbances from layers below resulting in the heating of the layers at least at this level (Punetha, 1974; Liu, 1974; Cram, 1974). A study of the temporal evolution of several of these profiles using the Ca II H line spectra of the Sacramento Peak Observatory vacuum telescope shows that enhancements as much as 40% in H_{2V} and H_{2R} emission and in the central depth of H_3 at the peak brightness phase during the course of evolution is not uncommon (Sivaraman, 1983). Above all, the association of these bright points with the photospheric magnetic elements of similar dimensions established by Sivaraman and Livingston (1982) adds further to the role that these structures can be expected to assume in the overall variation noticed in the K-line in

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the integrated sunlight. The solar cycle related changes in the parameters like $I_{K_{2V}}$, $I_{K_{2R}}$, I_{K_3}, the 1 Å K index and the K_2 half power width, that govern the shape of the K line profile have been studied by White and Livingston (1981) and these have been interpreted as wholly due to the addition of plages on the solar surface with the progress towards solar maximum. It may be pertinent in this context, to ask whether these bright points have any role at all in such changes in the profiles noticed over a solar cycle.

The two ways by which these bright points can participate in the solar cycle variation are by a change in their total numbers over the solar surface and by a change in their emission between the solar maximum and minimum. Here we report the results of an analysis which brings out the first aspect of their participation in the solar cycle changes.

2. Analysis of Observations and Result

The plate vault of the Kodaikanal Observatory of the Indian Institute of Astrophysics has an uninterrupted collection of spectroheliograms in K_{232} and Hα commencing from 1904 to the present day. We have picked up such K_{232} spectroheliograms that are properly exposed and were obtained under conditions of good seeing so that the identification of the bright points and their counts could be done with ease and certainty. Our sample consists of ten plates each for the years 1912, 1922, 1932, 1943, and 1953, representing the solar minimum epoch and for the years 1916, 1928, 1937, and 1946 representing the solar maximum epoch. On each plate we marked out an area covering 125 calcium network cells around the centre of the solar disk free from plages. We prepared photographic enlargements of these areas and made counts of the total number of bright points within the 125 cells from these prints. We made several prints with different exposures and chose that one which showed well all the fine details contained in the original spectroheliogram. The counts were done after shuffling all the prints belonging to the different epochs, so that while counting we were not biased by the information as to which year that particular print belonged to. Later the counts made by one individual was repeated many months later, by the same individual for a few cases as a check and these were further checked by another individual by choosing samples at random. The difference between the counts made at the three stages did not differ by more than 2% from one another.

Thus the total count of the bright points in a particular year is the number of bright points within 1250 cells, as we have made these counts on 10 plates for each of the years chosen. In Figure 1 we present these number counts against the year to which they pertain to. We have also included in this figure a plot of the calcium plage areas which are the daily mean values from Kodaikanal data (Kuriyan, 1967) to demonstrate the sunspot cycle. We find from the counts for the four cycles that the number of bright points vary in the same sense, as the solar activity. The results which we want to bring out would have been better demonstrated if plates, belonging to the exact years of maximum and minimum could have been used for the count like 1917 and 1948 for the maximum, 1923 and 1933 for the minimum and so on. Such a plan was limited for want of the required number of properly exposed plates suited for a study of this nature.

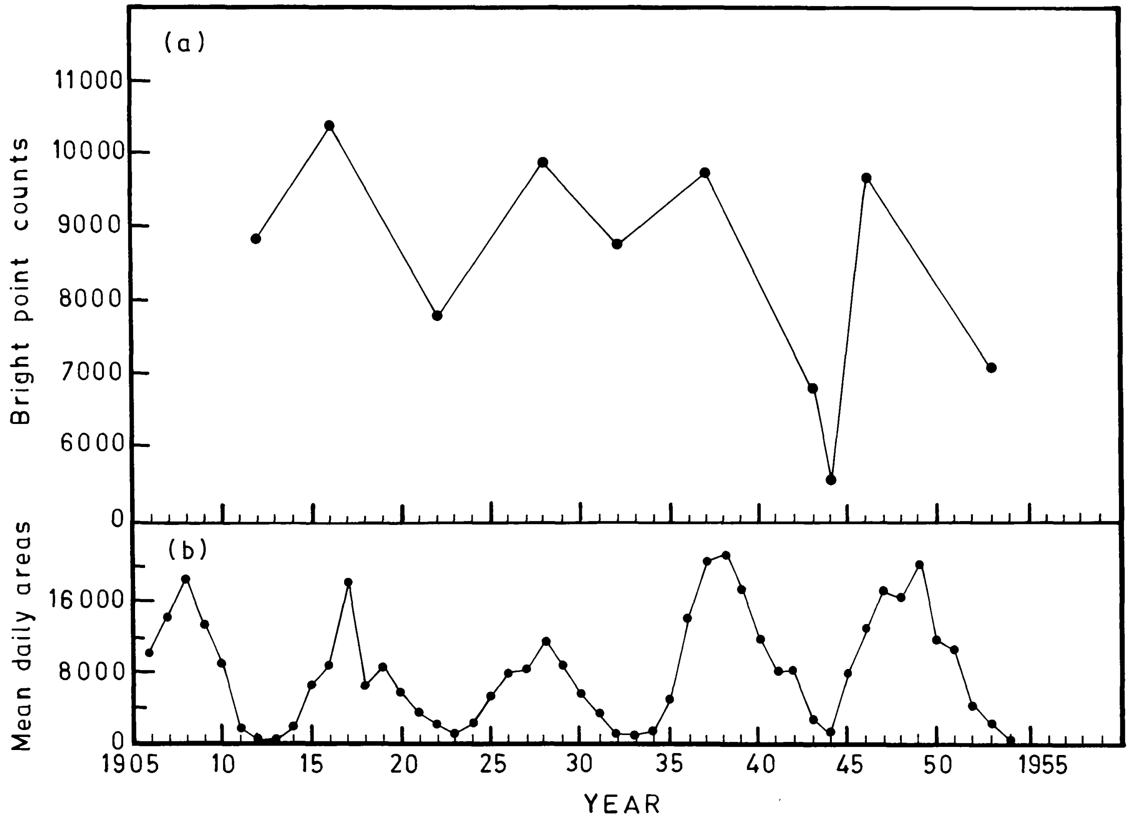

Fig. 1. (a) Plot of the bright point counts contained in 1250 network cells for four solar cycles. (b) Plot of the calcium plage area coverage on the solar surface for the years 1905–1954. These are the daily mean areas expressed in millionths of the visible hemisphere of the Sun.

The number of bright points during a solar maximum exceeds that during a solar minimum on an average by about 30%. Thus the integrated K-line profile of the Sun during a solar maximum does contain the cumulative contribution due to this excess number of bright points populating the solar surface compared to the solar minimum period. Although we have not attempted to make an actual count of these features at high latitudes as well as for longitudes closer to the limb where the foreshortening effect will make the identification of the individual bright points difficult, these fine structures in these regions would certainly show the same increase in numbers with the solar maximum as revealed in the present study. One other point that needs to be considered pertains to the solar faculae. Sheeley (1964) has determined the polar faculae distribution on the solar surface for three solar cycles. These faculae numbers are too small to have any significant contribution in the present context. Thus during the solar maximum the K-line profile of the integrated Sun derives its contribution not only from the plages, the well known predominent component, but also from the increased number of bright points that populate the rest of the area of the solar surface free from these plages. The enhancement in emission due to this increased number of bright points can no longer be considered less significant compared to the other components.

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