Abstract. The center-to-limb variation of the excess intensity in faculae was obtained for 266 active regions with an accuracy of $\leq 10^{-3}$. For this observation full-disk images were obtained with a rotating one-dimensional diode array whose rotation axis was set at the disk center, at the wavelength of 5450 Å with a bandpass of 400 Å. From the center-to-limb variation of excess intensity of active regions the excess effective temperature was found to be 6.4 K on the average where the mean longitudinal magnetic field is 65 G as measured by 5233 Å line. In other words the ratio of the excess radiative flux to the total flux was 0.44% on the average for the present measurements of low spatial resolution of 20″.

The average excess intensity for 60 active regions near the disk center was found to be $4 \times 10^{-4}$ of the quiet Sun intensity. This very low excess brightness averaged over the whole active region, in contrast to the reported high excess brightness of facular points (diameter $\approx 0.2''$) of $\approx 0.4$, leads to a hypothesis that the background in between facular points in the active region is darker than the true quiet photosphere by $\approx 1\%$. It is further surmised that the inferred darkness of intra facular points is due to partial compensation for excess total irradiance of facular points. This interpretation is also consistent with previous observations of the contrast of facular points near the limb.

1. Introduction

In this paper we report an observation of the center-to-limb variation (CLV) of the photospheric facular contrast by using whole disk images obtained with one dimensional rotating diode array whose axis of rotation is fixed at the disk center. The advantage of this method is that we need not correct the effect due to the limb darkening, nor calibrate the sensitivity of each pixel of diode array as long as we use the intensity of local continuum in the quiet atmosphere as a reference such as in the present study.

Frazier’s (1970, 1971, 1978) extensive observations have revealed that the excess intensity of the continuum as well as the core of an absorption line is a unique function of longitudinal magnetic field both in the quiet region and active regions. Although this observational finding has an essential bearing on the physics of individual facular points, it is necessary to know precisely CLV of excess brightness of active regions in order to study the energy balance (or imbalance) of active region as a whole. And yet this line of investigation has not been performed with enough accuracy and coherency, though a number of reports studying individual facular CLV exist (see references in Hirayama et al. (1984)).

It has become recently clear that photospheric faculae are composed of $\approx 0.2''$ size structure and their brightness near 5500 Å is 20–40% brighter than the adjacent region even in the disk center (e.g. Muller and Keil, 1983; Frazier and Stenflo, 1978).

On the other hand Foukal et al. (1981) found that the color temperature (not the brightness temperature) in faculae is lower near the disk center than in the limb. This
situation was expected in certain type of models where the temperature in a facula is higher at all geometrical height than in the quiet atmosphere, because of the opacity effect of negative hydrogen (see Figure 7 of Hirayama (1978)). However it was not evident whether an active region as a whole is darker or brighter in the disk center as compared to quiet regions, and the present observation shows that they are on the average only 0.1% (or less) brighter than the quiet region when seen at 5450 Å with a bandpass of 400 Å. This is by one order of magnitude lower than that expected (≈1%) from the high intensity of resolved facular points seen also with a wide bandpass and from the known fractional area covered with facular points. To resolve this discrepancy we introduce a working hypothesis that the background region in between facular points is dark by 1% (or less). Since a facular point is a net excess emitter, theoretically it may not be unreasonable to assume a dark region in a place where a facular point of a lifetime of ≈20 min (Muller, 1983) existed previously.

To study the above mentioned problems we constructed a small telescope which can measure precisely the intensity of the whole disk (0.1% accuracy). Besides these questions we plan to investigate with this telescope such problems as 5 min intensity oscillations (on which we have already some positive results), the energy budget of spots and faculae, and large scale patterns in intensity, and hence the description of the instrument in Section 2 is somewhat in detail. Section 2 also gives the direct observational result of the CLV of the facular contrast. In Section 3 the implication of the very small excess brightness of active regions in the disk center is discussed.

2. Instrument and Observational Results

The telescope consists of only an objective lens (5 cm effective aperture, doublet, \( f = 1.5 \text{ m} \)) and a rotating linear array detector (reticon type, 20 \( \mu \text{m} \times 20 \mu \text{m} \times 864 \) elements: Matsushita MN 864) in the focal plane (Figure 1). The intensity data are transferred through a slip ring to an AD converter and then to a micro-computer for 256 different position angles during a 6s rotation period. The pixel size in radial direction is 2.75", while the tangential spatial resolution is varying and lowest at the limb, 24".

Fig. 1. Schematic layout of the intensity-measuring telescope.