ON THE FINE STRUCTURE OF THE EVERSHED EFFECT

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Abstract. The fine structure of the Evershed effect was studied using spectrograms obtained on 3 July 1969 at the Pulkovo Observatory. The results of the study of FeI and CaI lines show that the outward motion in the penumbra is concentrated only in dark filaments. It is supposed that interfilamentary spaces are parts of the photosphere not covered by dark filaments. The velocity variation along a few dark filaments shows that maximum velocity is at a distance 0.8 $R_s$ from the center of the sunspot. The mean velocity in the interfilamentary elements is of the same order as that in the photosphere directly adjoining the penumbra. The results of measurement in TiII, FeII and CH lines show that in the colder upper part of the penumbra (CH) the velocity is greater than the velocity measured in the deeper layers (FeII and TiII). The mean velocity at the outer boundaries of the dark filaments (TiII) is 1.5–2.0 km/s.

Many problems on the velocity field in sunspots have not as yet been solved. There have been only a few investigations on the fine structure of the penumbra (Abdussamatov and Krat, 1970; Beckers and Schröter, 1967; Mattig and Mehlretter, 1967). In these studies the observations of radial velocities ($V_{rad}$) and magnetic fields ($H$) were usually made only in one direction — along the slit of the spectrograph and therefore did not give a full picture of the Evershed effect. Contradictory results on the magnetic field (Beckers and Schröter, 1967; Mattig and Mehlretter, 1967) and velocity (Abdussamatov and Krat, 1970; Beckers, 1966; Schröter, 1965) in the elements of the penumbra also require further investigation.

1. Observations

We obtained spectrograms which permitted a study in a wide range of wavelengths of the variation of the radial velocity in the penumbra in a three-dimensional system of coordinates: along the slit, along the diurnal parallel and with depth of the solar atmosphere. The data were obtained on 3 July 1969 with the four-camera spectrograph of the second horizontal solar telescope of the Pulkovo Observatory. The optical system of the spectrograph permits simultaneous photography of four different regions of the solar spectrum with an exposure time of 0.2 s and dispersion 1.16 mm/Å at Hα in the second order of the grating. The photographs of the spectra in the regions of Hα, D1 and D2 (NaI), Hβ, H and K (CaII) lines were made by the so-called escalation method (Abdussamatov and Stoyanova, 1968). This method permits us to obtain spectrograms of a selected area of the solar surface at equal intervals of distance along the diurnal parallel.

The investigated group of sunspots No. 239 (numeration in Solnechnye Dannye) had the heliographic co-ordinates $\phi = 15^\circ$S, $\lambda = 57^\circ$E at the time of observation (Figure 1). The spectrograms (Hα-region) of the corresponding cross-sections of the
Fig. 1. Sunspot no. 239. The cross-sections are numbered 1-5. The dashed line around the sunspot indicates the facular region.

Fig. 2. The spectrograms (Hα-region) of the corresponding cross-sections 1, 2, 3 of the penumbra.