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SPECTROSCOPY OF A SOLAR PROMINENCE WITH THE NARROW-BANDPASS FILTER

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Abstract. Observations and analysis of a quiescent prominence above the solar limb are presented. The set of quasi-monochromatic images of the prominence made in a few wavelengths of H_α, H_β and D_3 lines have been used for reconstruction of the coarse line profiles. Two-dimensional maps of the main physical parameters of the prominence matter-macroscopic and turbulent velocities, electron temperature, density and optical thickness have been constructed. Presented method of low-resolution spectroscopy is useful for investigations of the variety of large-scale solar phenomena.

One of the most important tasks of the recent observational heliophysics is the simultaneous analysis of the main physical parameters in all solar structures observed as two dimensional objects, made on a basis of a multi-line spectroscopy (for instance, spectroscopy of a whole solar prominence above the solar limb). These data will provide information about some important questions like distribution and temporal changes of the of physical parameters of the matter.

I present here an analysis of a series of quasi-monochromatic images of a prominence observed at 1990.10.06 from 1630 UT to 1700 UT above the solar limb at PA(H) $= 80°$. Fifteen sets of the images have been taken in centers and wings of H_α, H_β and D_3 lines with the Universal Birefrigent Filter (UBF) of the Vacuum Tower Telescope (VTT) of the Sacramento Peak Observatory for the following wavelengths:

H_α line: λ_0, $\lambda_0 \pm 0.2$ Å, $\lambda_0 \pm 0.4$ Å, $\lambda_0 \pm 0.6$ Å, $\lambda_0 \pm 0.8$ Å, $\lambda_0 \pm 1$ Å;
H_β line: λ_0, $\lambda_0 \pm 0.2$ Å, $\lambda_0 \pm 0.4$ Å;
D_3 line: λ_0, $\lambda_0 \pm 0.1$ Å, $\lambda_0 \pm 0.2$ Å, $\lambda_0 \pm 0.3$ Å, $\lambda_0 \pm 0.4$ Å.

The pass-bands of the UBF filter for these lines were 109 mÅ, 56 mÅ and 86 mÅ, respectively. The total time of taking one set of images (i.e., effective temporal resolution of the observations) varied from 115 to 126 seconds, depending on the current transparency of the air. During the period of observations seeing was relatively good and the spatial resolution achieved was of about 1 arcsec. The observations have been recorded on Kodak 2415 film. The accuracy of the photometry is about 5%. The main source of errors was the fringe's pattern added to images during the microphotometry. It was caused probably by the interference of a laser beam of the microdensitometer in thin layers between the film and the covering glass.

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All the frames have been spatially coaligned using images of two reference points made in the artificial moon placed just behind the UBF at the main focus of the VTT. The relative shifts of each frame in a constant reference co-ordinate system of the first frame have been calculated and reduced. This procedure removes the spatial errors caused by the UBF filter with prefilters, photocamera and microdensitometer. The accuracy of the method was about 1 arc sec. The atmospheric refraction has been also taken into account during the calculations.

The images have been used to reconstruct the coarse line profiles and to determine time and spatial evolution of some physical parameters of the prominence matter: maximum emission intensity I_0 [erg/cm^2/srd/s/Å], total emission intensity I_c [erg/cm^2/srd/s], FWHM $\Delta\lambda_{0.5}$ [Å] and Doppler shift $\delta\lambda_{\mathrm{Doppl.}}$ [Å]. Comparing observed intensities of the emission with values computed by non-LTE escape probability code written by Heinzel and Novocký (see Wiik *et al.*, 1992). I was able to estimate the temperature, turbulent velocity, electron density and optical thickness in the main body of the prominence: T = 6,000 - 13,000 K (T_{mean} = 8,000 K), $N_e > 10^{11}$ cm^{-3}, $\tau(\mathrm{H}\alpha) > 5.8$, V_{turb} = 9 - 14 km/s ($V_{\mathrm{turb\ mean}}$ = 11 km/s).

The observed prominence may be divided into three main parts: relatively quiet main part of the prominence body, loops filled by fast moving matter and a transition region between the loops and main body where matter moved more or less chaotically. One can have an impression that some kind of a piston has pressed the matter from the transition region to the loops.

This method of low-resolution spectroscopy seems to be very good for statistical investigations of large-scale solar phenomena but, similarly as perhaps more superior MSDP technique. The main difficulty and sources of errors during analysis of this kind of observations are: problems with spatial adjusting of images taken non-simultaneously, problems with photometrical calibration and variable influence of the atmospheric seeing.

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