

## THE INFLUENCE OF BELGRADE SOLAR SPECTROGRAPH'S APPARATUS FUNCTION ON LINE PROFILES

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**Abstract.** The apparatus function of Belgrade solar spectrograph for different entrance slit width is determined using the He-Ne laser 633 nm line. CCD spectrograms of 0.25 nm wavelength interval at  $\lambda = 630$  nm were taken with different entrance slit widths. The Fourier transform method is applied for deconvolution of corresponding instrumental profiles. It is shown that the central intensity and the full width at half maximum of reconstructed line profiles of strong spectral lines do not depend on the entrance slit width, but for weak spectral line such a dependence is evident for entrance slit widths wider than 150  $\mu\text{m}$ . The equivalent width is invariant with respect to the entrance slit width variation.

### 1. INTRODUCTION

The solar spectrograph of Belgrade Astronomical Observatory is a Littrow type with a Baush and Lomb replica grating (600 lines/mm, 206 × 154 mm area). It is completely presented by Kubičela (1975). The instrumental profile of this spectrograph, with a photographic camera as a receiver, was determined in 1983 by Jankov (1985). Since then, the spectrograph was modified twice. In 1986 it was converted into a scanning spectrometer by adding to it an exit slit and replacing the photographic camera with a photomultiplier (Arsenijević et al. 1988). An optical scanner was used for scanning of about 0.48 nm wide spectral region in 4th order spectrum. In 1994 we converted the spectrometer again into a spectrograph, but now with an SBIG ST-8 CCD camera as a receiver. Besides these transformations the spectral apparatus underwent some changes. So, in 1994 the unwanted interference fringes in CCD images have been removed by tilting the plane of the CCD receiver for 5.°2 with respect to the optical axis of the spectrograph Littrow lens (Kubičela et al., 1994), and in 1995 a mechanical exposure trigger was removed from the optical path of the CCD camera.

Due to these changes it was necessary to determine the Belgrade solar spectrograph's apparatus function again, and to analyse its influence on observed spectral line profiles. In this paper we present the results of this analysis.

## 2. INSTRUMENTAL PROFILE

The instrumental profile of the spectrograph was measured using the 633 nm line of a He-Ne laser. The coherence of the laser beam was broken down by a piece of drafting paper in front of the entrance slit. The spectrograph was fed by laser beam using a  $3 \times 2$  cm flat  $45^\circ$ -mirror. The illumination of the entrance slit was position-dependent. For determination of instrumental profile we used only those parts of entrance slit image that had more than 5000 (to avoid the low signal to noise ratio) and less than 65000 (to avoid the non-linearity effects caused by saturation) counts. (The whole dynamic range of the CCD receiver is  $2^{16}=65536$ ). The instrumental profiles normalized to unit area, were determined for 12 different entrance slit widths (ESW = 25  $\mu\text{m}$ , 50  $\mu\text{m}$ , 75  $\mu\text{m}$ , 100  $\mu\text{m}$ , 125  $\mu\text{m}$ , 150  $\mu\text{m}$ , 175  $\mu\text{m}$ , 200  $\mu\text{m}$ , 225  $\mu\text{m}$ , 250  $\mu\text{m}$ , 275  $\mu\text{m}$ , 300  $\mu\text{m}$ ). As examples, in Figure 1. four of them are presented. One can notice a systematic blue asymmetry, i.e., an intensity excess in the blue wing of the line profile. In Figure 2. the dependence of the full width at half maximum (FWHM) on entrance slit width (ESW) is presented. For ESW values under consideration, FWHM increase almost linearly.

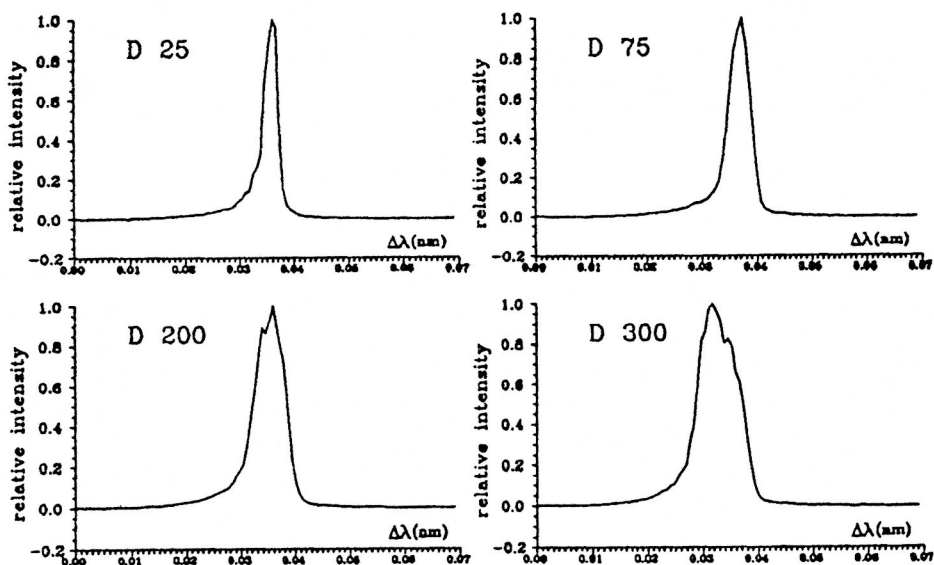


Fig. 1. The instrumental profiles for four different entrance slit widths

## 3. OBSERVATIONS AND REDUCTION

We observed the spectral region about 0.3 nm wide, near 630.2 nm with four spectral lines. Two of them are of solar origin (FeI 630.2000 nm and FeI 630.2499 nm) and the other two are telluric lines (O<sub>2</sub> 630.1508 nm and O<sub>2</sub> 630.2764 nm).

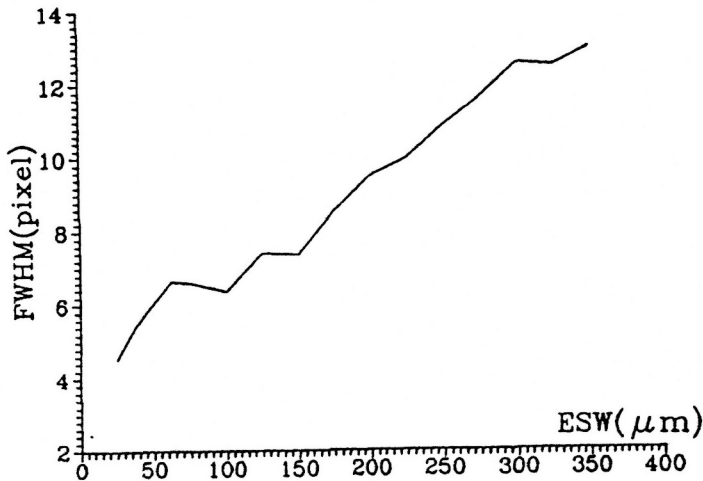


Fig. 2. The dependence of FWHM of the instrumental profile on ESW

CCD spectrograms of this region were taken for the same 12 different entrance slit widths as for the instrumental profile. The CCD image consists of 375 pixels (375 pixel columns) along the dispersion, and about 50 pixels perpendicularly on it (pixel rows). The CCD counts were converted into the relative photometric intensities using the ANALYST program package (Malkov, 1996), which gives an average values along the pixel columns. For flat-field reduction we used a second-order polynomial fit to the local continuum points (highest points) of the spectrum. The same polynomial we used for normalizing the continuum to unity. The dispersion was determined from two observed solar spectral lines taking the minimum of parabola fit put through several (about 10) measured points around the line cores. It is equal to  $6.898 \times 10^{-4}$  nm/pixel (1 pixel = 23 μm).

A fast Fourier-transform algorithm (Jankov 1994) was used to filter out the high frequency noise (cutoffs were from 16-29 pixel<sup>-1</sup>) and for deconvolution of the corresponding instrumental profiles.

For further analysis we used the relatively strong FeI 630.2000 nm line and the weak O<sub>2</sub> 630.1508 nm telluric line. These two lines allowed the analysis of the influence of instrumental profile at different entrance slit width on strong and on weak line profiles.

#### 4. RESULTS

We compare the equivalent widths (EW), the intensity at line core (I<sub>c</sub>) and the full width at half maximum (FWHM) for different widths of the entrance slit (ESW). These parameters were normalized to their values at the first width of entrance slit. The results are presented in Figure 3. We can see that the parameters of the reconstructed strong FeI 630.2 spectral line profile do not depend on the ESW for the range under consideration (from 25 μm to 300 μm). For the weak telluric line the EW is independent on the entrance slit width, but obviously this is not so for the I<sub>c</sub> and FWHM. Their values increase with increasing entrance slit width, especially for values greater than 150 μm.

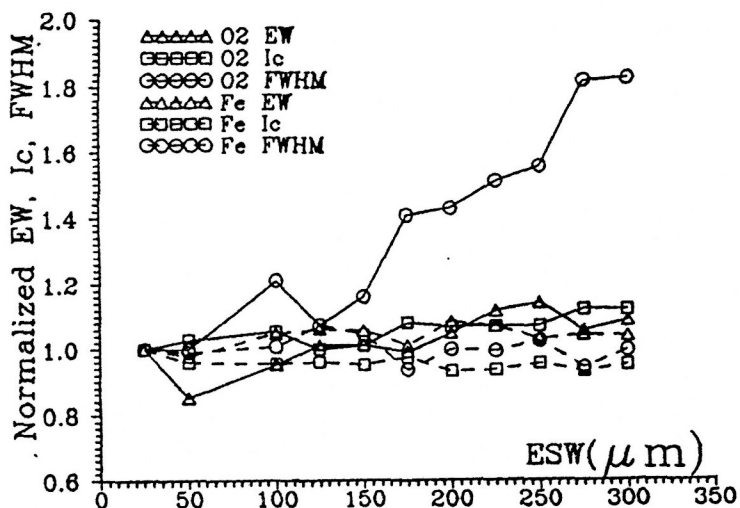


Fig. 3. The dependence of the EW, the Ic and the FWHM of O<sub>2</sub> and Fe lines on ESW

## 5. CONCLUSIONS

Using a He-Ne laser source we determine the instrumental profile of Belgrade solar spectrograph for different values of entrance slit width from 25  $\mu\text{m}$  to 300  $\mu\text{m}$ . We can conclude that the equivalent width of reconstructed spectral line does not depend on the entrance slit width in the given range. The central intensity and the full width at half maximum of the reconstructed line profile of the strong spectral line do not depend on the entrance slit width, but in the case of a weak spectral line such dependence is evident for entrance slit width wider than 150  $\mu\text{m}$ .

## Acknowledgements

We thank Dr. Slobodan Jakov for his computer program for deconvolution of the instrumental profile. This work is a part of the project Astrometrical, astrodynamical and astrophysical researches, supported by Ministry of Science and Technology of Serbia.

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