

STELLAR SPECTROGRAPH OF THE BELGRADE ASTRONOMICAL OBSERVATORY

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Abstract. The main features of the new SpectraPro-750 spectrograph of Belgrade Astronomical Observatory are given in this paper. The instrumental profile of the spectrograph for the 1200 l/mm grating is determined using a fiber optic bundle with fibers arranged in a pseudo-slit pattern. This instrumental profile is compared to the instrumental profiles obtained when the same fiber optic bundle illuminates the entrance slit at different widths from appropriate instrumental profiles. The practical spectral purities and the spectral resolutions for different entrance slit widths are obtained. The variation of the reciprocal linear dispersion with wavelength in the spectral range 350 - 600 nm is presented.

1. INTRODUCTION

SpectraPro-750 is the new fiber-fed spectrograph intended for use primarily at the new 60 cm Cassegrain telescope. The optical setup of telescope-spectrograph link will be adapted to this telescope. The spectrograph has been planned for the recording of low-resolution spectra of relatively faint stars and asteroids, medium-resolution spectra of relatively bright stars and studies of the variations in highly broadened spectral line profiles. It is suitable both for determination of gas movements in circumstellar disks and radial velocity measurements of close binary stars, where velocities of several hundred km/s are often observed.

In this paper we present the main characteristics of this instrument, its supplement accessories, instrumental profile and the results of experimentally obtained reciprocal linear dispersion in the spectral range from 350 to 600 nm.

1. 1. EXPERIMENTAL SETUP

The experimental layout is shown in Fig. 1. The SpectraPro spectrograph is equipped with two active ports: the entrance and the exit port. At entrance port there is a permanent adjustable entrance slit and an imaging fiber adapter. The exit port with a detector adapter permits the mounting of a CCD camera. The CCD camera is controlled by the ST-133A Controller. A fiber optic bundle allows the spectrograph to be fed by light from a spectral calibration lamp. The operation of spectrograph

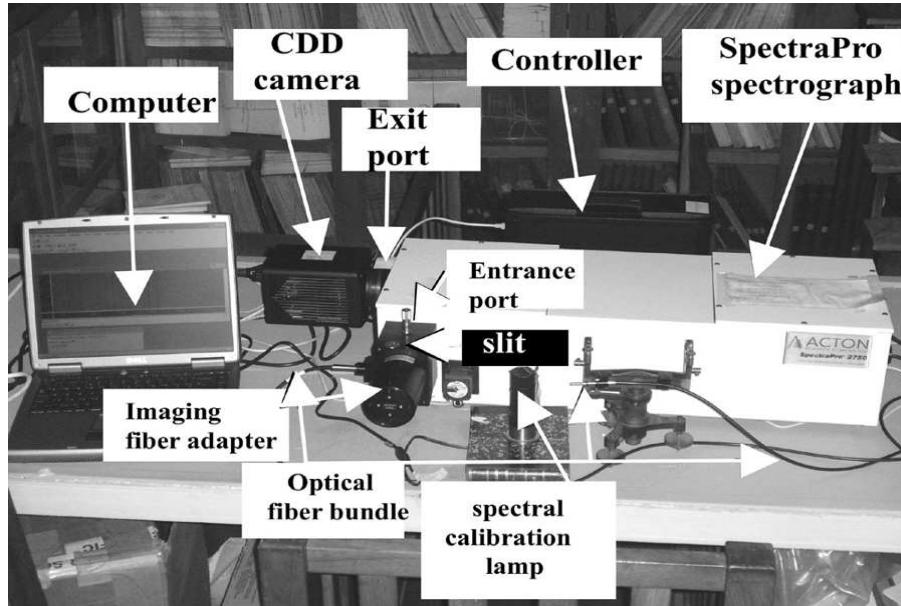


Figure 1: Experimental setup

and the CCD camera is controlled by a computer using the WinSpec/32 software package for spectroscopy.

The SpectraPro spectrograph is intended for spectral recording and analysis in spectral regions from violet to infrared. The spectrograph is equipped with three $68 \times 68 \text{ mm}^2$ ruled diffraction gratings: 300 l/mm, 600 l/mm and 1200 l/mm, all blazed at 500 nm. The entrance slit width is micrometer adjustable. The detector system is a Spec-10 detector, optimized for spectroscopic applications. It consists of a CCD camera head and a controller. The spectral range covered by a single CCD image depends on the reciprocal linear dispersion. The full well capacity of the pixels is 500000 electrons. The dark current is $0.8 \text{ electrons px}^{-1}\text{s}^{-1}$. The spectral calibration lamp is a pencil-shaped discharge lamp containing argon and mercury Hg(Ar). The lamp produces narrow and intense lines from UV (starting at $\sim 185 \text{ nm}$) to IR (ending at $\sim 1710 \text{ nm}$), suitable for wavelength calibration.

1. 2. RECIPROCAL LINEAR DISPERSION AND RESOLUTION

Reciprocal linear dispersion of SpectraPro spectrograph was measured at five, about 6 nm wide, spectral ranges around 350 nm, 400 nm, 430 nm, 550 nm and 580 nm using a $10 \mu\text{m}$ wide entrance slit and the 1200 l/mm grating. The reciprocal linear dispersion was obtained by calibration of the observed solar spectrum using the solar spectral line atlas of Moore et al. (1966). Line identification was carried out by comparing the observed spectrum with that of the solar spectral atlas (Delbouille et al., 1973). During this procedure some difficulties in spectral line identification arose,

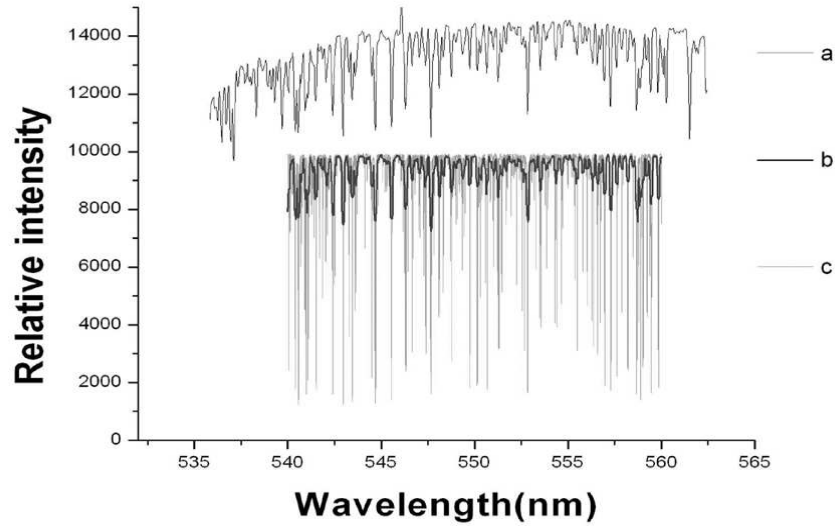


Figure 2: Observed solar spectrum (a), smoothed solar spectrum atlas (b) and spectrograph in the first order with grating high-resolution solar spectrum atlas (c) 1200 l/mm.

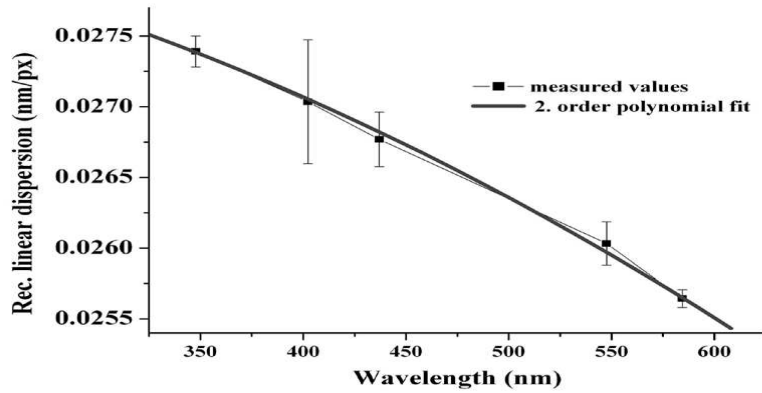


Figure 3: Reciprocal linear dispersion curve.

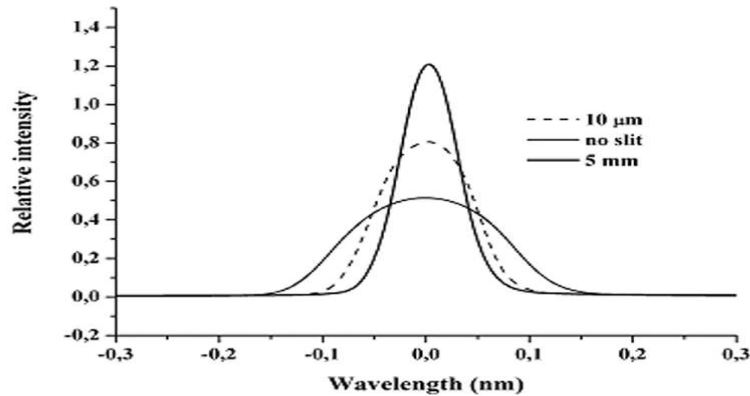


Figure 4: Instrumental profile for slit widths of $5 \mu\text{m}$ and $10 \mu\text{m}$.

due to the very different resolutions of the observed and compared spectra. These problems were, for some spectral regions, overcome by smoothing the high-resolution solar spectrum until its resolution became comparable with that of the observed one. For illustration see spectra in Fig. 2.

The measured reciprocal linear dispersion values in every spectral range were averaged and this average value was associated with the corresponding central wavelength of the spectral window. The variation of the reciprocal linear dispersion (nm/px) with wavelength is shown in Fig. 3. Taking into account the pixel size ($26 \mu\text{m}$) we obtain 1.02 nm/mm at 500 nm , in good agreement with the value 1.1 nm/mm given in specification of Acton Research Corporation.

For determination of the instrumental profile we used our Hg(Ar) spectral lamp. As a first approximation we assumed that spectral lines produced by this spectral lamp have negligible widths in comparison with the width of instrumental profile. Thus the spectral line profile produced by Hg(Ar) lamp represents the instrumental profile. We assumed further that the measured full width at half intensity maximum (FWHM) is equal to the practical spectral purity. Fig. 4 shows the obtained (instrumental) profiles for the 576.9 nm spectral line.

For our spectrograph the resolution at basic slit width should be about 68000. Our measurements gave only about 9300. The discrepancy between these values is mainly due to sampling pattern of the detector (CCD chip). Namely, it is required that each independent point at detector is sampled by a slightly more than two sampling elements (pixels). In our case this corresponds to about 0.05 nm , which leads to a resolution of about 10000. This value is in good agreement with the measured one. On the other hand, when the spectrograph is illuminated by the pseudo-slit of fibers, the size of the fiber image ($200 \mu\text{m}$) will define the resolution. The fiber image is sampled with about 7 pixels that give 0.18 nm for the spectral purity. Then the resolution is 3200, which is in good agreement with the measured value (~ 3300). That means that

the Doppler-velocity measurement accuracy of our spectrograph is about 100 km/s. From this discussion we can conclude that for improvement of velocity measurement accuracy it is necessary to increase the dispersion. It can be done by increasing the grating constant or by using higher-order spectrum.

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