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Order-separating prism for camera 2 of the BTA MSS

G.A. Chountonov

Special Astrophysical Observatory of the Russian AS, Nizhnij Arkhyz 369167, Russia

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Abstract. An order separator for camera 2 of the Main Stellar Spectrograph of the 6 m telescope which makes it possible to obtain simultaneously ordinary and Zeeman spectra in the 2-nd and 3-rd orders is described. Its parameters and results of testing in BTA observations are presented.

Key words: telescope — instrumentation: stellar spectrograph: prism

1. Introduction

An optical scheme of the Main Stellar Spectrograph (MSS) of BTA (Kopylov and Rylov, 1979) is presented in Fig. 1. The MSS incorporates a collimator (3) and a slit (1), which are common to the three cameras, while cameras 2 and 3 have a common frame for diffraction gratings (2). For separating a working order coloured glasses are used in camera 2. Having earlier an internal focus, at the present time the camera is fitted with a diagonal mirror positioned so as to bring the focus out of the camera, and with a platform to hold a CCD of 1040 × 1160 pixels (the pixel size is 16 × 16μm). Vignetting of the beam of light has been obviated; large diffraction gratings, 320 × 360 mm (Panchuk, 2001), have been purchased and installed.

The spectrum is positioned along the columns of the CCD which records about 250 Å in the second order in the red region, or about 160 Å in the third order in the blue region. Camera 2 is equipped with different type (4 types) analysers of circular polarization and until very recently was chiefly used to measure magnetic fields of stars.

2. Description of the order–separating prism

The order separator makes it possible to record simultaneously the spectrum regions of the 2nd and 3rd orders without employment of order–separating filters. With this order separator one can measure magnetic fields from the lines H_α and H_γ. It was designed with allowance made for the characteristic properties of the circular polarization analyser, i.e. the separation of orders is about twice the height of the spectrum. Different layouts of the separator were computed with the package ZEMAX–9 for the available sorts of glass. A composite forward prism made of K–8 and TF–7 glass with aberrations less than 15 μm reduced to the spectrograph slit was chosen to be optimal separator as regards its quality and ease of fabrication. A schematic view of the separator is displayed in Fig. 2. It is a prism consisted of three prisms cemented together: two similar outer prisms made of glass K–8 with an angle at the top of 9.8° and a TF–7-glass prism between them with an angle of 13.6°. In the central part the prisms are 7, 10, 7 mm thick, respectively.

An arrow in Fig. 1 indicates the location of the order separator in the spectrograph. The separator is mounted on an arm supporting the diffraction grating (2) at a distance of 2 m from the slit (1). The light beam diameter here is about 60 mm. The angular dispersion of the prism makes it possible to

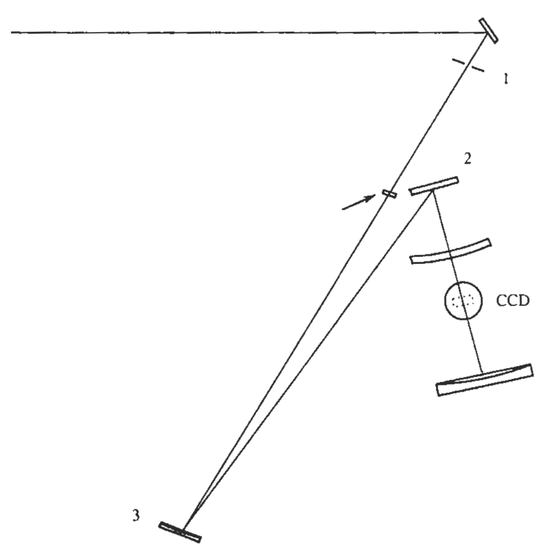

Figure 1: *An optical scheme of the MSS. The location of the order separator installed in the MSS is indicated by the arrow.*

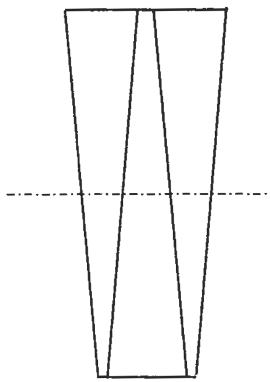

Figure 2: *A schematic view of the order separator.*

separate spectra to a distance corresponding to 50–70 CCD pixels. The light beam broadening on the collimator (at a focal length of 7929 mm) along the prism dispersion is 33 mm. The light spot diameter on the collimator is 7929 mm/31 = 256 mm at f/31. The sum of the spot size and that of broadening is 256 + 33 = 289 (mm), which is less than the collimator diameter, 300 mm. The beam size on the grating is 289 + 33 = 322 (mm), and is nearly equal to its transverse size. Thus, there is no vignetting of the beam on the collimator and grating.

Fig. 3 shows a comparison spectrum produced by a Th–Ar lamp in the region 6120 Å (lower) and 4080 Å (upper) obtained with the circular polarization analyser. The spectra taken without the order separator are straight, while those obtained using the separator are slightly curved. In the red spectrum region the curvature is so small (the right side of the spectrum lies by only 3 pixels below the left one) that it can be processed in the MIDAS package with the aid of the programme for a long slit. The blue spectrum region is curved greater (both sides of the spectrum differ in height by about 10 pixels), the package for processing echelle spectrograms should therefore be used here.

Fig. 4 displays the variation of the distance between the spectrum centres of the 2-nd and 3-rd orders against the 2nd order wavelength. The horizontal line represents the distance between the Zeeman spectra. It can be seen from the figure that the orders overlap at the waves longer than 7200 Å.

Basic parameters of the order separator:

- size across the beam axis — 70 × 70 mm;
- glass thickness in the central part — 24 mm;
- mean distance between the spectra in the 2nd and 3rd orders (pixel size — 16 × 16μm) — 60 pixels;
- limiting wavelength in the 2nd order, at which no overlap of the 2nd and 3rd orders occurs yet — 7200 Å;
- ultimately short wavelength in the 3rd order (transmission 70 %) — 3800 Å.

Fig. 5 illustrates the spectra of the magnetic star α^2CVn obtained with the order separating prism and circular polarization analyser around the hydrogen lines H_α and H_γ. The pronounced difference in intensity, which is also demonstrated by the cross section of the spectra (Fig. 6) is caused by a higher dispersion of the camera in the 3rd order (1.5 times) as compared to the dispersion in the 2nd order and low sensitivity of the CCD in the blue region. The spectra were taken at twilight. The magnetic field was measured from the hydrogen lines and made 540 G from H_α and 770 G from H_γ. The difference lies within the measurement errors. The field strength is consistent with the measurements made by Borra and Landstreet (1977) from the Balmer hydrogen line.

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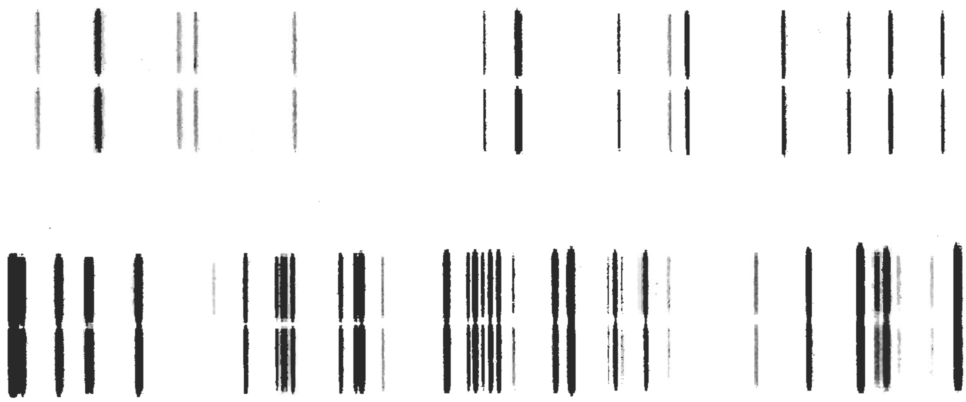

Figure 3: *The comparison spectrum of Th-Ar in the region 6120 Å (bottom) and 4080 Å (top) obtained with the circular polarization analyser.*

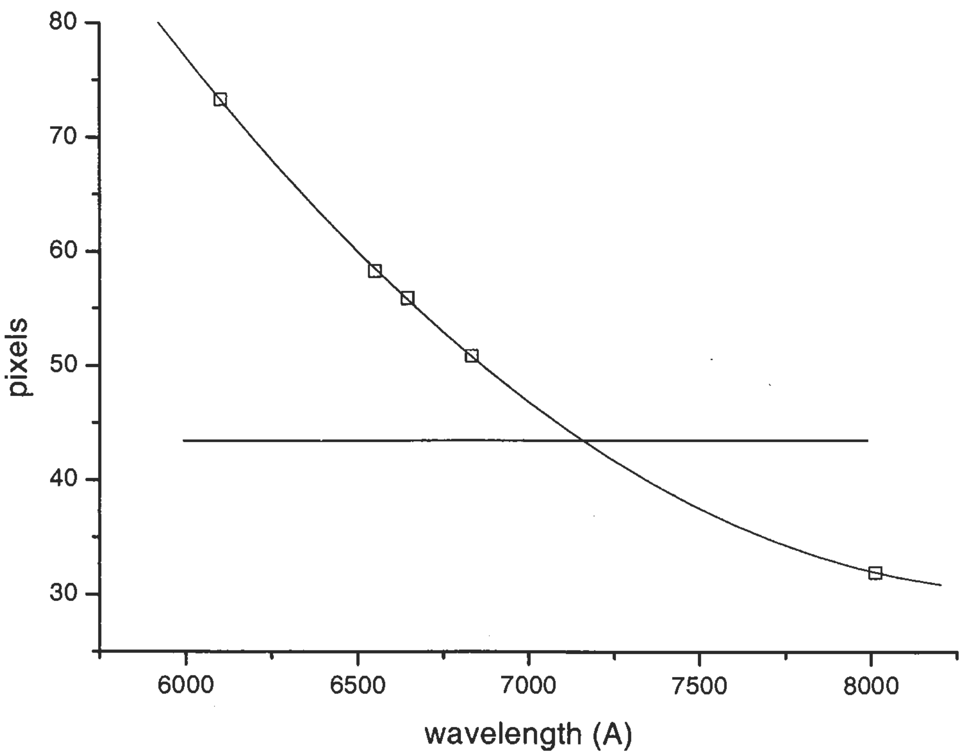

Figure 4: *Distance between the spectrum centres of the 2nd and the 3rd orders as a function of the wavelength of the 2nd order.*

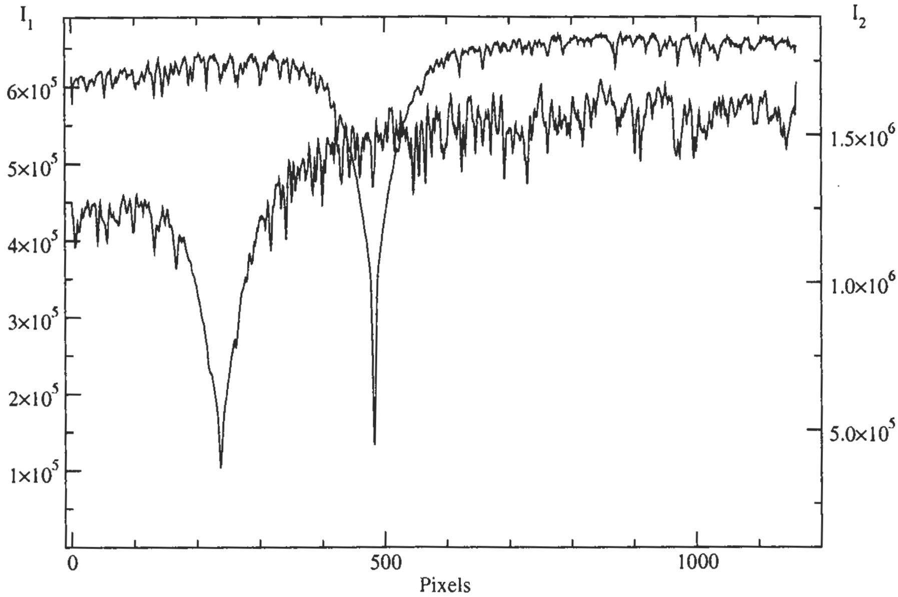

Figure 5: *Spectrum regions of* α^2 *CVn around* H_α *and* H_γ.

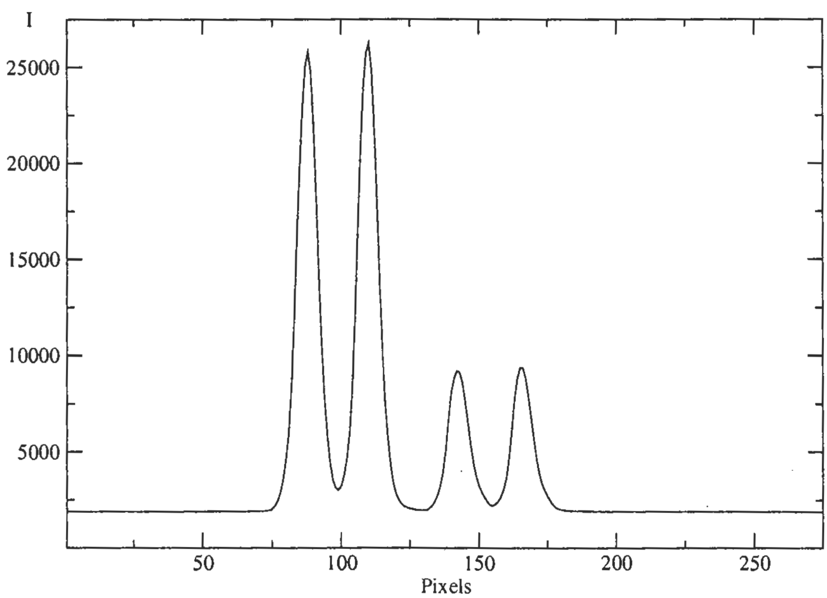

Figure 6: *Spectrum section of* α^2 *CVn across the dispersion.*