The new circular polarization analyser for the Nasmyth-1 focus of the 6 m telescope

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Abstract. A circular polarization analyser for the Nasmyth-1 focus of the 6 m telescope is designed. The device widens the scope of polarimetric investigations of unique objects. Examples of the first advantageous applications of the analyser are given.

1. Introduction

One of the most efficient methods of studying stellar magnetism is obtaining of Zeeman spectra. In "photographic" epoch, when photoemulsion was the main light receiver, such spectra were taken with the circular polarization analysers attached to the entrance of high-dispersion classical spectrographs (Babcock, 1952; Najdenov and Chountonov, 1976; Glagolevskij et al., 1976; Bychkov et al., 1988). These spectrographs had very good position stability which permitted study and allowance for all instrumental effects appearing in measurements. This is of special importance since the spatial separation of spectra in orthogonal polarizations occurs perpendicularly to the dispersion direction, i.e. the appearance of the second dimension causes Zeeman spectrograms to be processed as two-dimensional images. The new solid-body detectors, with limited linear sizes, called for employment of echelle spectrometers producing a large number of geometrical distortions, especially in taking Zeeman spectra. For the purpose of correct separation of information and instrumental effects in Zeeman spectra a new analyser was designed. The general principle of the analyser is the possibility of changing the sign of the circular polarization with the complete preservation of the optical path by means of turning a quarter wave phase shifting plate by 90°.

2. The circular polarization analyser

Consider the performance of the circular polarization analyser the schematic of which is displayed in Fig.l. At the entrance of the analyser $\lambda/4$ (90°) plate, a linear phase shifting element, labeled "in" in the figure, is inserted. The azimuth of the axis of the highest speed of this element makes an angle of 45° with the azimuth of the axis of the highest speed (accordingly an angle of -45° with the lowest speed axis) of an Iceland spar crystal following the plate. The Iceland spar crystal is intended to spatially separate two mutually

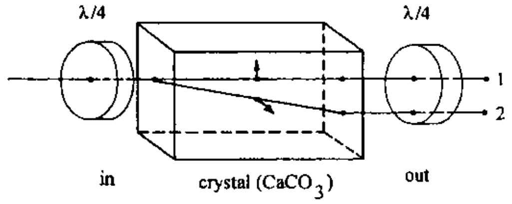

Figure 1: *The schematic of the circular polarization analyser.*

orthogonal linearly polarized beams of light produced by the entrance phase shifting plate. The exit phase shifting plate $\lambda/4$ (90°) ("out" in Fig.l) transforms linearly polarized light into circularly polarized. The exit plate is oriented in the same way as the entrance one to eliminate instrumental effects that arise when the light is reflected from the diffraction gratings. The elements incorporated in the analysers employed previously were immovable and used to stick together with the Iceland spar crystal after orientation. In this case the two outgoing beams of light had circular polarization of definite sign. Using such analysers with echelle spectrometers involves difficulties in taking account of the two-dimensional spectrum distortions. In our case the analyser is fitted with a precision mechanical unit that turns the entrance quarter wave plate "in" by 90°, which leads to a change of sign of circular polarizations of the output beams (denoted by 1 and 2 in Fig.l). Here the light beams, having changed the sign of polarization, are projected on the same elements of the detector. By making two successive exposures of the object with different positions of the entrance plate, obtain images of Zeeman spectra with equal distortions but having an opposite direction of the Zeeman effect. This method makes the most correct separation of instrumental effects from the measured Zeeman effect. The parameters of the analyser are listed in Table 1.

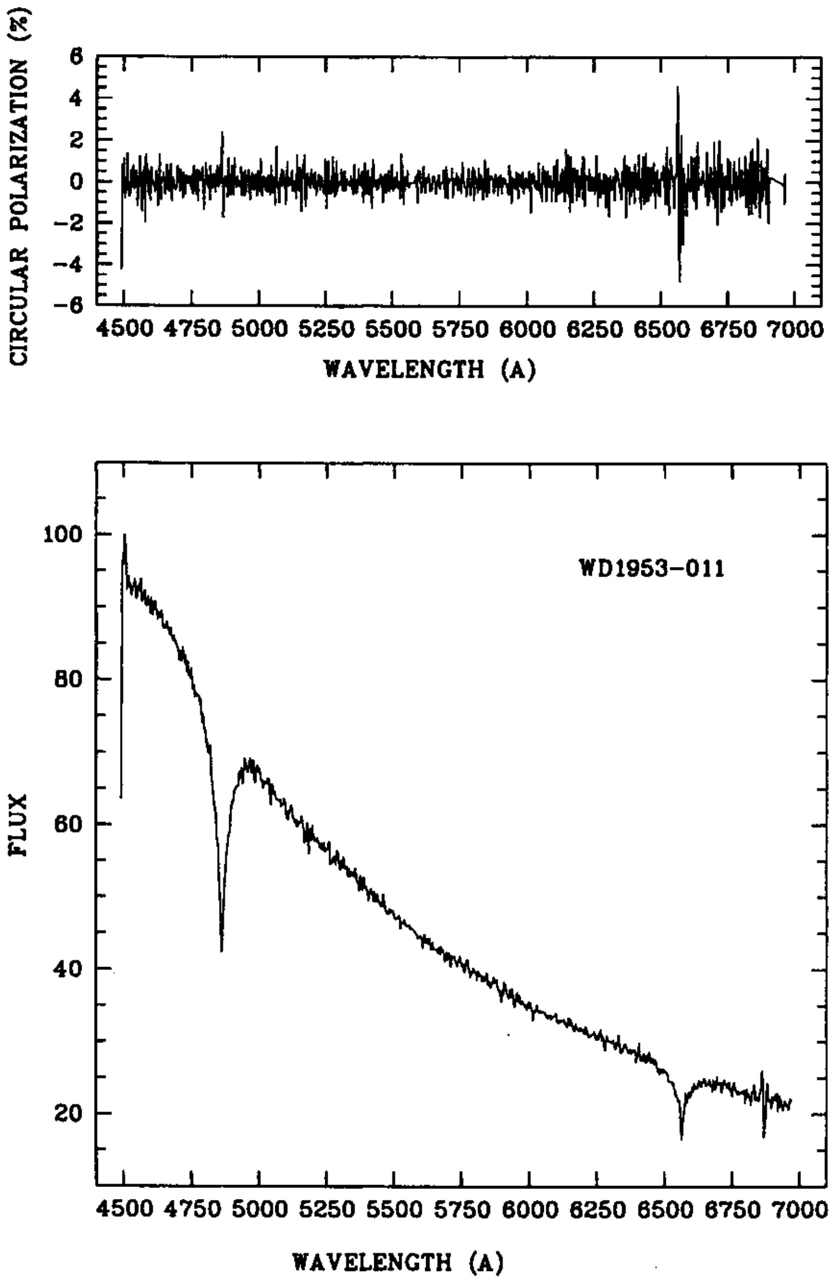

Figure 2: *Upper panel: distribution of circular polarization over WD 1953-011 spectrum. Polarization jumps are well seen in the wings of hydrogen lines. Lower panel: the spectrum of WD 1953-011 obtained as the sum of spectra in two circular polarizations.*

Table 1:

Division of beams	7 mm
Division of beams in arcseconds	7″
Throughput in the blue region 4000 — 5000 ÅÅ	32 %
Throughput in the red region 6000 — 7000 ÅÅ	37 %

The throughput of the analyser was measured from observations of the star 53 Cam with the spectrograph SP-124 in the Nasmyth-1 focus. The small changing throughput in a wide wavelength range is an outstanding advantage of the analyser.

The analyser was tested in observations of the well-known magnetic star 53 Cam. The results show a good agreement with previous behaviour of 53 Cam magnetic field.

The analyser is made so that it can readily be operated at the two Nasmyth foci of the 6 m telescope in conjunction with any devices.

The first astrophysical observations with the analyser, which are worthy of note, are demonstrated in Fig.2. The lower panel of this figure displays the spectrum of the magnetic white dwarf obtained as the sum of spectra in two circular polarizations. The upper panel shows the distribution of circular polarization over the spectrum of this object. In distribution of polarization one can well see the polarization jumps in the wings of hydrogen lines. The magnetic field estimated from these data is H_e = 25 ± 6 kG. Fig. 3 presents a magnetic curve of WD 0009+501. The estimates of the magnetic field for this object have been made from 31 Zeeman spectra: 21 spectra in one position of plate, $\lambda/4$ "in", (filled circles) and 10 spectra with the plate turned by 90° (open squares).

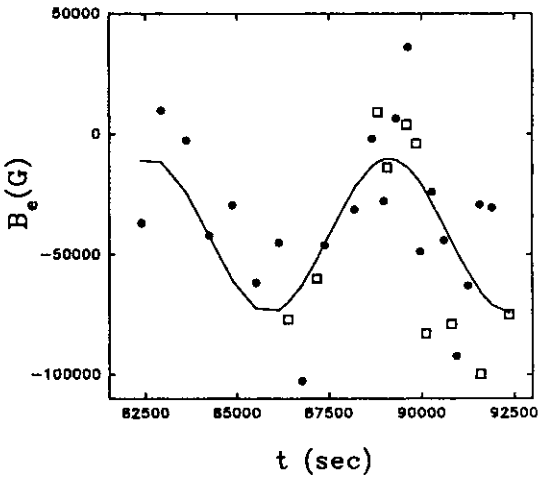

Figure 3: *The magnetic curve of the white dwarf WD 0009+501.*

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