Instrumental depolarization at the coude focus of the 1 m telescope of SAO RAS

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Abstract. We report on instrumental depolarization at the coude focus of the SAO 1 m telescope. On the basis of direct measurements we have estimated the value and behaviour of circular instrumental depolarization.

1. Introduction

As for the procedure, polarization measurements appear to be the most complicated. The measurement results are strongly affected by instrumental effects, which introduce additional polarization in radiation, distorting thereby useful information. This well-known problem was discussed in detail by Babkock (1958), Wolff and Bonsack (1972), Borra and Vaughan (1977), Nariai (1982), Capitani et al. (1989), Bychkov et al. (1999) and a number of other authors. Instrumental effects not only introduce additional polarization, but also weaken polarization of the input light. This problem is of our concern in this paper.

2. Observation

To investigate into the value of instrumental circular depolarization, a beam of light polarized circularly to a degree of 100 % should be sent to the entrance of the light transmission system. In order to perform this study with the utmost correctness, it was decided to make a polarization calibrating device which would transform the input nonpolarized light into circularly polarized without deflecting the incident beam. The device was made from two properly oriented phase shifting plates, $\lambda/2$ and $\lambda/4$. Knowing that the primary and secondary mirrors do not introduce essential distortions, we have installed a calibration device behind the secondary mirror, in front of the first inclined diagonal mirror (for optical scheme see Bychkov et al., 1999). The estimates of the expected polarization made on the basis of the known parameters of phase shifting plates and light filter are given in Table 1.

Table 1: *The estimates of the expected polarization (V Stokes parameter) for each filter*

Filter	P %
U	63.1
B	82.4
V	87.9
R	83.7
I	52.6

To measure the circular instrumental polarization, the polarimeter MINIPOL was placed at the coude focus of the 1 m telescope. Zero-polarization standards (Table 2) were used in the measurements. The circular polarization measurements were made in the standard Johnson photometric system UBVRI with the calibration device on August 13/14, 1998. Three stars (Table 2) were used in the measurements. The standard exposure time was 1 min. The accuracy of one measurement ranged from 0.2% to 1.5%.

Table 2: *Zero polarization stars used in measurements*

Name	m_v	α	δ	Sp
αLyr	0.03	18 36 56	+38 47 01	*A0V*
αPeg	2.49	23 04 46	+15 12 19	*B9V*
γCas	2.47	00 56 43	+60 43 00	*B0IV*

To calculate instrumental depolarization, a system of coordinates, used by Bychkov et al. (1999), has been used. Using the expression for transformation of Stokes vector $S(I, Q, U, V)$ in the general matrix form according to Schurcliff (1962)

$$S' = T_5 \times R(\Theta_2) \times T_4 \times R(\Theta_1) \times T_3 \times S \qquad (1)$$

and the data on the computed polarization value for each filter (Table 1), we can calculate theoretical relationship between the expected polarization and the hour angle.

3. Discussion

From all the available data for the 3 stars, the mean ratio of the measured circular polarization (V Stokes parameter V_m) to the calculated polarization (V_{calc})

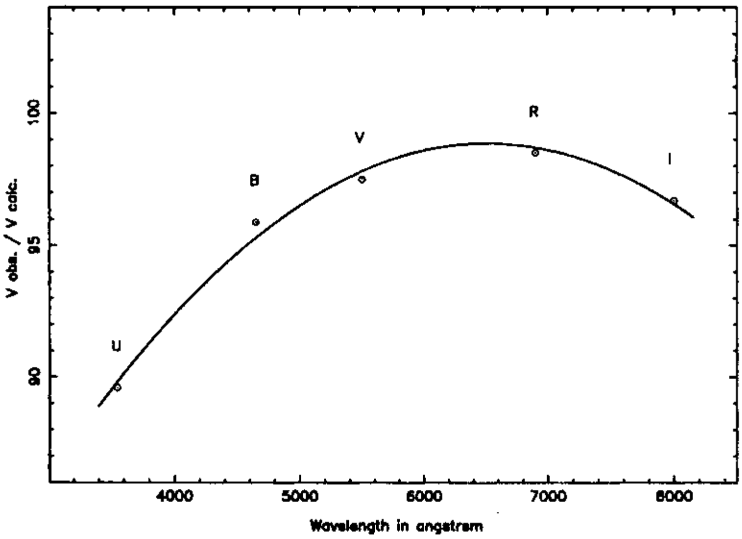

Figure 1: *The depolarization obtained as a function of the wavelength.*

Table 3: *Coefficients k and depolarization values for each filter*

Filter	Centre λ(Å)	k %	Dep %
U	3550	89.6	10.4
B	4650	95.9	4.1
V	5500	97.5	2.5
R	6900	98.5	1.5
I	8000	96.7	3.3

has been found. It represents the part of circular polarization left after reflection of the light beam by the tilted diagonal mirrors:

$$k = 100\% \cdot V_{obs}/V_{calc}. \quad (2)$$

For taking account of the instrumental effects, this is the most convenient way of expressing depolarization in relative units, but not in terms of relative phase shift in the wave front. The convenience is due to the fact that the detector (generally a CCD) records the intensity of radiation but not the phase shift between the Fresnel amplitude coefficients of the electric vector r_s and r_p. We find the depolarization as:

$$Dep = 100\% \cdot (V_{calc} - V_{obs})/V_{calc}. \quad (3)$$

The data obtained are presented in Table 3 and Fig. 1.

It can be seen from these data that the highest depolarization is observed in the ultraviolet region, in the *U* filter, and increases somehow in the infrared region, in the *I* filter. There are grounds to believe that the observed instrumental effects vary "slowly" with wavelength. That is why, for the sake of convenience of taking them into account, an analytical expression describing the behaviour of k with wavelength has been derived:

$$k = 55.1983 + 0.134146 \times \lambda - 1.03047 \times 10^{-6} \times \lambda^2. (4)$$

4. Conclusions

As a result of the work accomplished, we have managed to measure the instrumental circular depolarization and trace its behaviour with wavelength. The data allow correct account of the instrumental effects arising in magnetic measurements.

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