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CALIBRATION OF *uvby* PHOTOELECTRIC SYSTEM IN AO BELOGRADCHIK

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Abstract. In this paper the calibration of the *uvby* system established in AO Belogradchik is presented.

Резюме. Описана реализация системь *uvby* в АО Белоградчик и её калибровка.

1. Introduction

Today the four-colour intermediate band *uvby* system [3] prevails as a photometric system which combines well the requirements of the informative and efficient photometric observations. It is probably the most useful one for obtaining astrophysical information. Selecting the four intermediate transmission bands one can measure details of the stellar spectrum which allows the temperature, the surface gravity and the metalicity of the stars to be determined with minimum inherent mutual dependence.

In the last year efforts have been made to establish this system on the 0.6-m reflector of Astrononical Observatory (AO) Belogradchik. The present study is on the calibration of this system including derivation of extinction and transformation coefficients. Software for observational data reduction is briefly described. This study sets the beginning of a continuous observation of the extinction and parameters concerning this photometry at AO Belogradchik. That is a necessary condition for obtaining precise photometric results.

2. Observation

The observations were carried out during August 13–17, September 25, 28 and 29 and October 16, 17 and 18, 1990. Eight of the nights were photometric and they are listed in the first column of Tables 1 and 2. The telescope was equipped with EMI6224 photomultiplier and *uvby* set from the South African Astronomical Observatory (SAAO). The transmission curves of the filters are given in Fig. 1.

Each measurement included photometry of the star in the sequence *ybvuuvby* and of the background in the sequence *ybvu*. For the standard stars during each sequence 10 samples (integration times 1 s) for each filter were made. The standard stars were selected from [2]. Almost all suitable for observation during this time of the year stars with magnitudes fainter than 4.5 mag, covering a wide range of spectral ($B-G$) and luminosity ($I-V$) classes were included. Based on these data the extinction coefficient behavior was investigated and the coefficients for transformation to the standart *uvby* were determined.

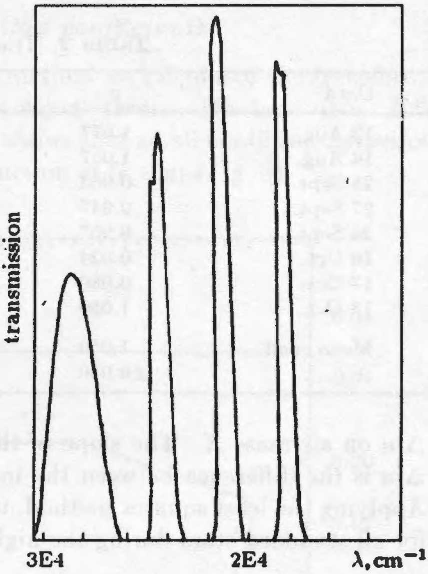

Fig. 1. Filters transmission curves

Table 1. Extinction coefficients

Data	k_y	K_{c_1}	K_{v-b}	k_{b-y}
13 Aug.	0.924	0.023	0.303	0.190
14 Aug.	0.259	0.293	0.159	0.129
25 Sept.	0.107	0.076	0.195	0.109
28 Sept.	0.411	0.210	0.157	0.135
29 Sept.	0.253	0.193	0.197	0.110
16 Oct.	0.463	0.104	0.178	0.061
17 Oct.	0.513	0.211	0.116	0.109
18 Oct.	0.434	0.351	0.187	0.121

3. Reduction to the Standard System

The accepted transmission band half-width of the *uvby*-filters simplifies the transformation to the standard system. Their small widths make the colour effects in the Bugert lines negligible. Thus the introduction of a second extinction coefficient depending on the energy distribution in the star spectrum is not necessary. The *u*-filter is centered away from the atmospheric boundary at 300 nm and the observatory altitude is not so significant.

3.1. *Determination of the extinction coefficients*

The most simple and easy method to determine the extinction coefficients is to observe stars at different zenith distances and to determine the dependence of

Table 2. Transformation coefficients

Data	y	c_1	$v-b$	b-y
13 Aug.	1.077	0.999	0.995	0.941
14 Aug.	1.057	1.014	0.985	0.961
25 Sept.	0.963	1.002	1.010	0.919
27 Sept.	0.947	0.981	1.033	0.913
28 Sept.	0.967	0.997	1.005	0.930
16 Oct.	0.924	0.983	0.997	0.906
17 Oct.	0.980	1.010	1.055	1.004
18 Oct.	1.050	1.006	1.022	0.949
Mean coeff.	1.050	0.999	1.013	0.940
	±0.050	±0.010	±0.020	±0.030

Δm on air mass X. The slope of the latter gives the extinction coefficient. Here Δm is the difference between the instrumental and the standard star magnitude. Applying the least squares method, the extinction coefficients of y, c_1, m_1 and $b-y$ for all standard stars during the night are determined (Fig. 2). The calculation of

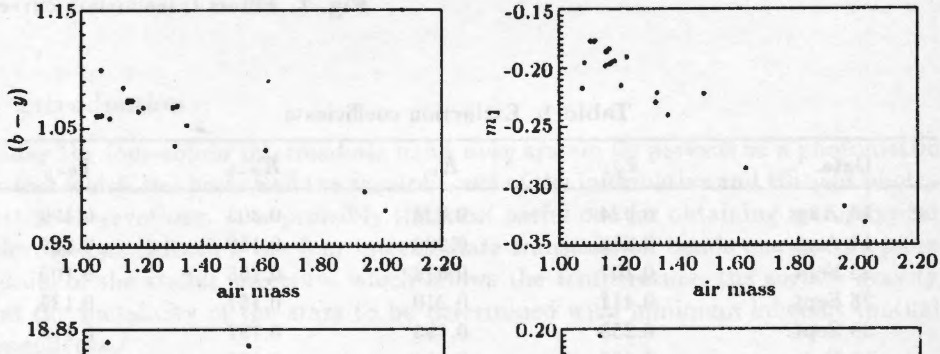

Fig. 2. Typical Bugert's curves for observing run. Data from September 28, 1990

the extinction coefficients of the colour indices and differences but not in the star magnitudes is preferred because of the higher accuracy that can be achieved. The coefficients for each night are given in Table 1. The standard error in these values is less than 0.01. They clearly show that it is impossible to obtain the average coefficients for several nights. The reduction must be done with current night extinction coefficients. This procedure was strongly recommended also in [4].

3.2. *Determination of the transformation coefficients*

Following [1] and applying the least squares method we calculated the transformation coefficients for each night first without colour terms. The behaviour of the residuals from all nights after this reduction shows that small nonlinear corrections are required for V, $(b-y)$, c_1 and m_1 as function of $(b-y)$ (Fig. 3).

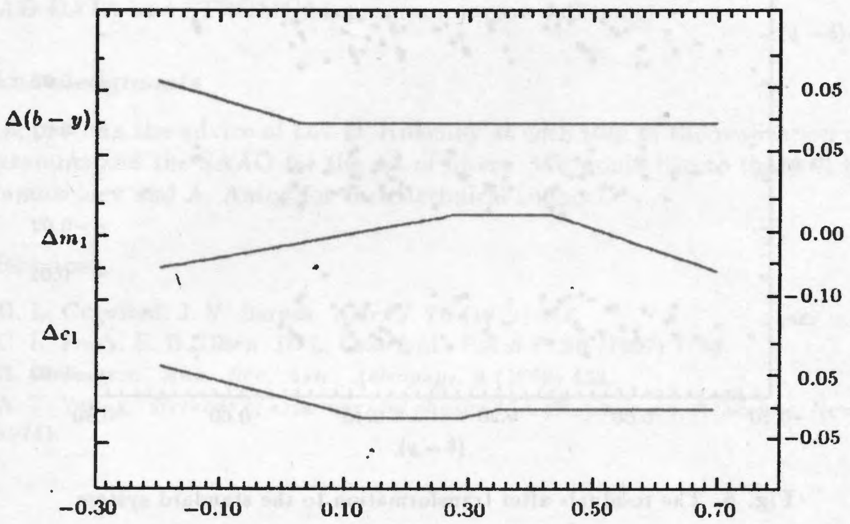

Fig. 3. Nonlinear corrections applyed

The linear reduction coefficients for each night are shown in Table 2. The standard error here is less than 0.01. These coefficients show great stability from night to night and the mean values can be used. Based on all data, the nonlinear corrections were also determined. At the end the data were reduced using the mean value of the first coefficients and the nonlinear colour corrections for the whole observing run as follows:

$$V = 1.050y_i + 0.06(b-y)_i$$
$$(b-y) = 0.940(b-y)_i + \Delta(b-y)$$
$$m_1 = 1.013m_{1i} + \Delta m_1$$
$$c_1 = 0.999c_{1i} + \Delta c_1$$

where "*i*" indicates the instrumental values.

A mean-point was determined for each night. Small zero-point corrections were applied as a smooth function of time where necessary. Fig. 4 shows the residuals of the standard stars' quantities after the whole transformation.

Taking into account the effects of wearing out of the filters, a continuous check of the transformation coefficients is reasonable. We consider that the optimal procedure of data reduction is to determine the extinction coefficients each night. The

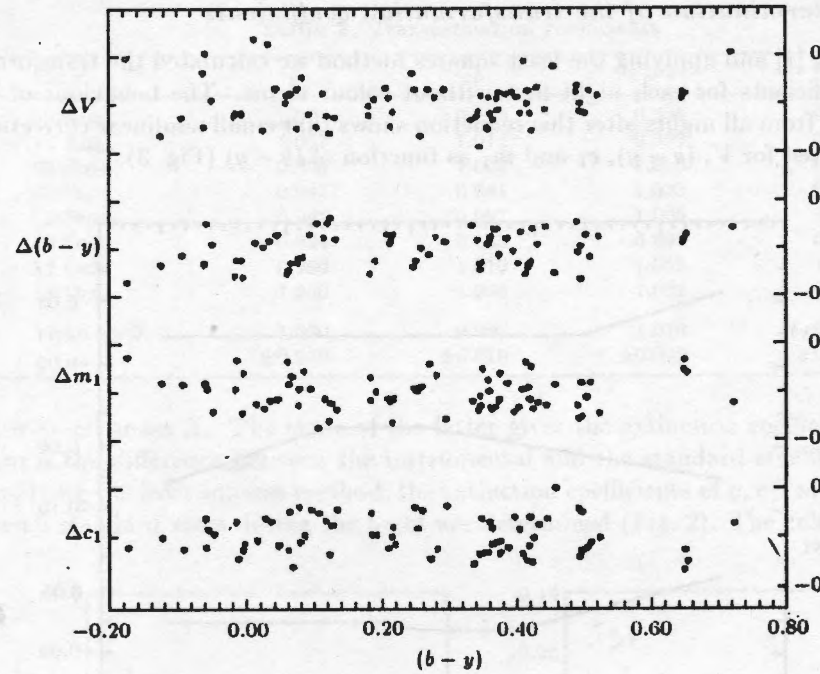

Fig. 4. The residuals after transformation to the standard system

transformation to the standard system should be carried out based on the average coefficients from several consecutive nights.

4. Reduction Software

Two basic algorithms for data treatment are known. The first one is based on the use of windows. The second one is more flexible: each step of the reduction is represented by a separate command. It makes possible optional sequences of procedures to be carried out by the user without fixing the algorithm. The second method is useful when reduction technologies are built.

The packet StromPhot includes four programmes realizing the procedure described above. The first programme READ-DATA reads the file with rough data stored during observation and calculates the instrumental star magnitudes. Here we note that calculating magnitudes we use the median of each set of samples instead of the average value. Thus, the manual correction of accidental errors during data transfer is avoided. The star magnitudes and the observation time are written in a separate file for further treatment.

EXT programme determines the extinction coefficients. The calculated star magnitudes and colour differences and indices of the standard stars are compared to their catalogue values and applying the least squares method the extinction coefficients are obtained. Visual control of the fit is available.

ST programme detemines the coefficients of transformation to the standard system. The procedure corrects the magnitudes and the colours of the standard stars with user defined extinction coefficients which need not be the over obtained from the preceding command. The transformation coefficients are determined from the extra-atmospheric values and the catalogue data applying again the least squares method.

STROMCAL programme completes the whole treatment. With the transformation and reduction coefficients already set, the programme makes a reduction of the programme star data. If the coefficients are known from other sources the READ-DATA and STROMCAL programmes are sufficient.

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