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UV-PHOTOMETRY WITH THE 1.2 M SCHMIDT TELESCOPE IN BALDONE

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ABSTRACT. The University of Latvia's Institute of astronomy possesses a collection of 22 thousand photographic plates taken by the 1.2 m Schmidt telescope located at the Baldone observatory. Among others, there are 767 astronegatives in this collection obtained in 314 sky areas using the Johnson U-filter. The field of view of each negative covers 19 square degrees. The plate scale is 72"/mm. The digitizing of the UV-collection has started in June 2016 with EPSON EXPRESSION 10000XL flatbed scanner. The general aim of the digitizing is to obtain UV-magnitudes and positions of all objects registered on the plates. Up to date near a half of the UV-collection is digitized. 24 digitized MEGA program plates of the collection were used for the preliminary investigation of the quality of photographic material and scanner systematic behavior. The catalog of positions and UV-magnitudes of 68.784 stars and galaxies for 12 regions allows evaluating the expected accuracy of the whole observed material. The estimated accuracy for all objects is $\sigma_{\alpha\delta} = \pm 0.28$" and $\sigma_U = \pm 0.20^m$ for positions and brightness respectively. For the stars with $U = 8^m - 14^m$ these errors are $\sigma_{\alpha\delta} = \pm 0.11$" and $\sigma_U = \pm 0.09^m$. The convergence of coordinates with respect to the coordinates of the reference system Tycho2 is $\sigma_{\alpha\delta} = \pm 0.06$". The conformity with photoelectric Upe-magnitudes is $\pm 0.13^m$.

Keywords: digital image processing, ultraviolet, star catalogues

1. Introduction

The fields of interest of wide band UV-photometry used to be the vicinity of flare stars (or the supernova), the fields of active galaxy nuclei, the star formation regions, the fields of clusters, the dwarf nova, quasars and black holes (Wils, 2010; Krawchuk, 2013). However, UV photometric observational data are considerably less than those derived in the blue, visible and infrared spectral ranges as it is clear from the VisieR database collection of catalogs and publications.

Baldone Observatory of Institute of Astronomy, Latvian University possesses the photographic collection of 22 000 astroplates obtained using 1.2 m Schmidt telescope (Eglitis, 2016). The observational period started in 1966 and lasted for 39 years. The area of the sky, covered by a single plate is approximately 19 square degrees and contains from 10 000 to 50 000 images of different celestial objects. The image scale is of 72 "/mm. Plates were obtained with two exposures of different duration with the shift of the telescope between them along both coordinates.

The digitizing of the UV-collection has started in June 2016 with EPSON EXPRESSION 10000XL flatbed scanner. Its photometric and astrometric characteristics were previously tested, and the optimum mode of scanning was found. Results of testing are given in (Protsyuk, 2014a; 2014b). Note, that random positional and photometric errors of the scanner for 1.2 m Schmidt telescope are 0.04" and 0.015^m correspondingly.

2. Sequence of plate image processing

Next processes of digitized negatives' processing are tested in the series of works and were realized in catalogs of celestial objects (Protsyuk, 2014c, Kazantseva, 2015, Yizhakevych, 2015, Andruk, 2016a, Andruk, 2016b):

1. Preliminary image processing in MIDAS/ROMAFOT software to obtain pixel coordinates X, Y and instrumental estimations of magnitudes of fixed objects.
2. Separation of objects into sets of two expositions for each plate.
3. Selection of Tycho-2 reference stars' set into reference file for each plate.
4. The preliminary solution of equations for rectangular and equatorial coordinates of the set of reference stars.
5. Correction of the rectangular coordinates of objects for the scanner systematic errors.
6. The reduction of rectangular coordinates X, Y of all fixed objects into the Tycho-2 reference system.
7. The reduction of instrumental photometric estimations to the Johnson photoelectric U_{pe} magnitudes.

The detailed description of the above said procedures is given in (Andruk, 2015).

3. Astrometric reduction into Tycho2 reference system

For all plates the reduction model was represented in the form of complete polynomials of the 6-th degree, supplemented by the members of the equation accounting the effects of coma, distortion, and magnitude equation (Andruk, 2016a; Eglitis, 2016a). The results of the astro-

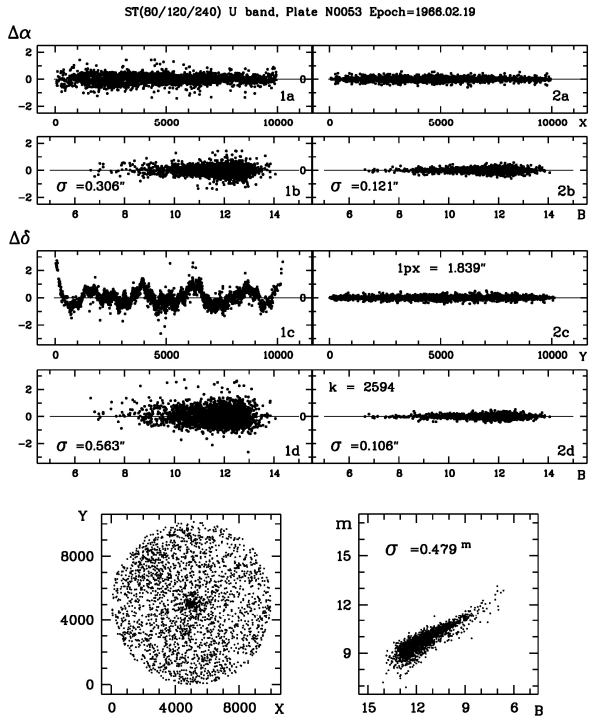

Figure 1: The results of the astrometric reduction into Tycho-2 system.

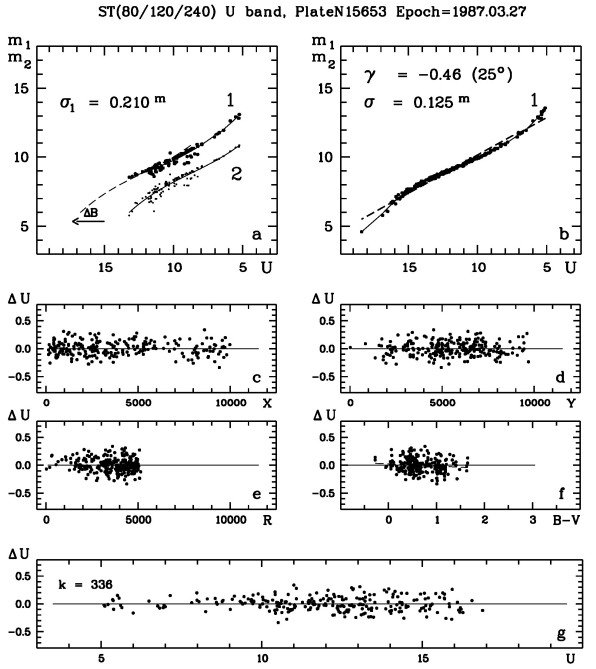

Figure 2: The results of the photometric solution for plates with two expositions.

metric reduction are shown in Fig.1. The epoch of the plate is 1966.02.12. Left and right panels show the differences of equatorial coordinates Δα, Δδ before and after the corrections for the systematic errors of the scanner. The differences of coordinates are represented in relation to pixel coordinates X,Y, and B-magnitudes from Tycho2. The lower panel depicts the distribution of Tycho2 stars over the field of the plate (on the left) and the connection of instrumental photometric m-values and B-magnitudes of Tycho2 (on the right).

4. Photometric reduction into the photoelectric U-magnitudes

The data from (Andruk, 1995; 1996a; 1996b; 1996c; Relke, 2015) catalogs were used for the calibration of characteristic curves, accounting for the photometric error across the field of view and the reduction of instrumental photometric values into Johnson photoelectric U_{pe} magnitudes. Characteristic curves were restored using photometric data of both exposures. The approximation of characteristic curves and derivation of photographic magnitudes U_{ph} ($U = U_{ph}$) for 24 plates were made by rms solution of the system of equations in the form of polynomials of the 5th degree. These equations describe the functional view of a characteristic curve with the members of equations accounting photometric error across the field of view (Andruk, 2016a; Eglitis, 2016a). The results of the photometric reduction for astronegatives with two exposures are represented in Fig. 2.

Here, the steps of the characteristic curve restoration are depicted (a,b). Panels c-g show the differences ΔU between U-magnitudes of stars calculated by characteristic curve and their photoelectric values. ΔU are given in relation to coordinates X and Y, distances from the center of the plate R, color index B-V and photoelectric U-magnitudes.

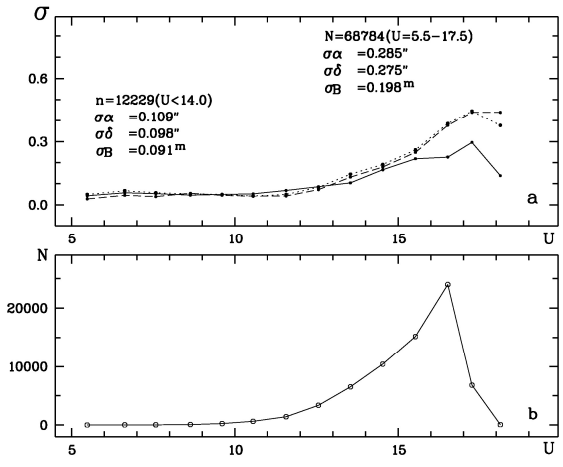

Figure 3: The trend of the internal errors for positions σα, σδ and magnitudes σU with U-magnitude (panel a) and the histogram of the distribution of the number of objects with U-magnitudes.

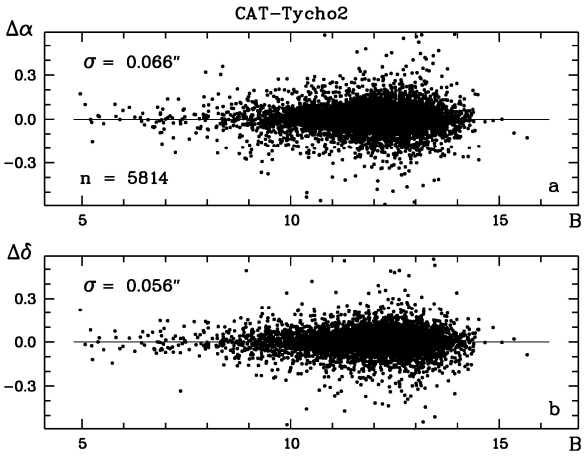

Figure 4: Positional errors for Tycho-2 stars in relation to B magnitudes from Tycho-2.

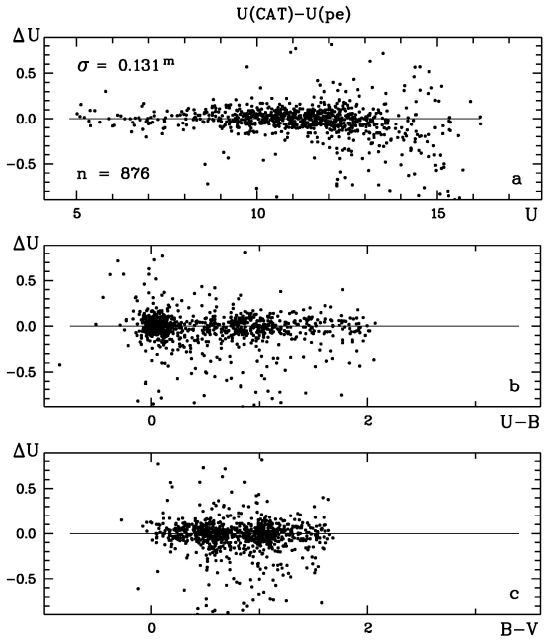

Figure 5: The comparison of derived U-magnitudes with photoelectric ones.

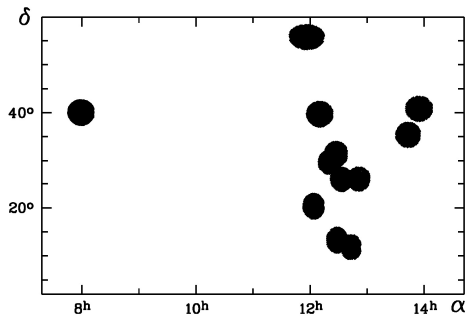

Figure 6: The distribution of 12 areas of MEGA program on the sky.

5. Catalog of U-magnitudes of MEGA program

After the treatment of 24 plates of MEGA program exposed in Baldone by 1.2 Schmidt telescope in U band, the catalog of positions and U-magnitudes for 68 784 stars and galaxies in 12 sky areas was made. Positions of objects are obtained in the system of Tycho-2, U-magnitudes are represented in the system of photoelectric standards. The internal accuracy for all objects is $\sigma_{\alpha\delta}$ = ±0.28" and $\sigma_U = \pm 0.20^m$. For stars in the range of magnitudes U = 8^m -14^m the correspondent errors are $\sigma_{\alpha\delta}$ = ±0.11" and σ_U = $\pm 0.09^m$ (Fig.3). The convergence of coordinates with the Tycho-2 reference system shown in Fig.4 is $\sigma_{\alpha\delta}$= ±0.06" (for 5 814 stars). The convergence with photoelectric U_{pe}-magnitudes is σ_B = $\pm 0.13^m$ (for 876 stars). The results of the comparison are given in Fig.5. The distribution of areas on the celestial sphere is represented in Fig.6.

6. Conclusion

For astronegatives with 2 exposures, the programing technique of characteristic curve restoration is developed and implemented for the creation of the catalog of positions and UV magnitudes of stars and galaxies. As a part of the UV collection is obtained with 1 exposure, it is necessary to find an empirical or analytical relation between measured and reference values of magnitudes in the case of absence of photoelectric standards in the section of extremely faint stars.

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