THE PHOTOMETRICAL SYSTEM AND POSITIONAL ACCURACY OF THE CCD CAMERA ST7 OF LISNYKI OBSERVATIONAL STATION

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The results of testing of CCD ST7 camera are reported. Determinations of photometrical system and positional accuracy were made by processing of open cluster Stock 1 observations at the AZT-8 telescope of the Lisnyki Observational Station.

PHOTOMETRIC SYSTEM

ST7 camera is mounted in the primary focus of the AZT-8 telescope (the Lisnyki Station). Transparencies curves of filters for CCD camera are measured using the SF-26 spectrophotometer. Pass bands of the V, R, I filters are close to pass bands of standard filters of the Johnson's system. Band B' is chosen with little displaced concerning standard in red side to provide whenever possible the best sensitivity of the camera.

The normalized filters curves of the camera were calculated taking into account sensitivity of the matrix, atmosphere transparency, and reflections from aluminium mirror in comparison with Johnson's standard system. These curves are shown in Fig. 1.

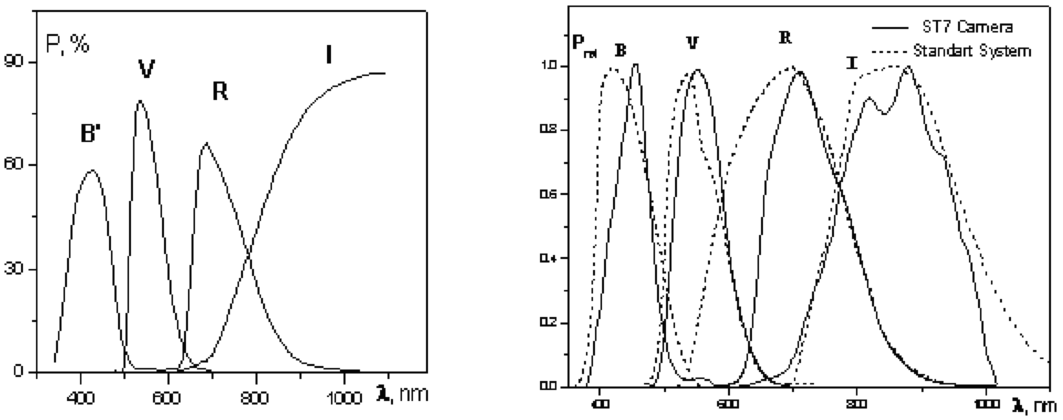

Figure 1. Transparency of the filter set (left) and the normalized filters curves of spectral transparency of the ST7 camera (right)

OBSERVATIONS

The observation for camera test was carried out on July 23, 2003 at the Lisnyki Observation Station. The camera was established in the primary focus of the AZT-8 telescope ($D = 0.7$ m, $F = 2.7$ m). For observation the area of open star cluster Stock 1 was chosen. Parameters of the CCD camera are such: the quantity of pixels is 765×510, the pixel size is 9 microns, the scale is $0.65''$ per pixel. Pair frames in the B, V, R filters, dark frames and flat field frames were obtained. The evening sky was used as source of regular lighted pictures for flat field frames. Time of exposures equaled three minutes.

Astroclimate of the Lisnyki Observational Station is characterized by such average values extinction: $K_U = 0.85^m$, $K_B = 0.46^m$, $K_V = 0.44^m$, $K_R = 0.12^m$. As for each industrial center, the observed surface brightness of a luminescence of the night sky in the Lisnyki astropoint strongly depends on zenith distance Z. The average data for four values $Z = 0°$, $35°$, $55°$, $60°$ have such size (in magnitudes per one square arcsecond): U = 20.35, 19.60, 18.75, 18.00; B = 21.10, 20.65, 20.35, 20.00; V = 20.20, 20.00, 19.60, 19.10; R = 19.95, 19.85, 19.50, 18.00.

PROCESSING

Processing of the CCD-frame is performed using the LINUX/MIDAS/ROMAFOT software [1]. The software (MIDAS procedures) cyclic processing of a final sequence of the numbered CCD-frames in format FITS is created in MIDAS environment. In process of data processing the astrometric and photometric characteristics of all registered objects in the frame were obtained. All the CCD-frames were processed one behind one without interfering of the operator. The frames obtained in B, V, R bands of Johnson's system were processed. The frame of photometric correction with dark frames (DARK) and flat fields (FF) were used average and normalized to an 60 s exposure. The astronomical frame was also reduced by the program to an 60 s exposure. Hot pixels were deleted using the median filter FILTER/MEDIAN with a window of scanning 3×3 elements. Instrumental accuracy of the measurement result was obtained for check of photometric parameters of the CCD camera.

Bright stars with bloom phenomenon are marked with a ring. This stars are brighter than $R = 14.5^m$. Accuracy of obtained rectangular coordinates X, Y and star magnitudes in instrumental *bvr* system may be estimated by comparison of the appropriate differences for two consistently observed frames. By results of observation on July 22, 2003 in Lisnyki for stars which are brighter than $R < 14.5^m$, the mean-square error of one measurement of rectangular coordinates X, Y and star magnitudes is $\sigma_{x,y} = \pm 0.058$ pixel, $\sigma_R = \pm 0.028$ mag. Dependence of the star magnitudes difference between two exposures was constructed on rectangular coordinates in frames. The results are given in Fig. 2. They show good uniformity of sensitivity because dependences on coordinates were not observed. Instrument magnitudes were compared with values from USNO-B catalogue [2] to check of a photometric scale. This catalogue was chosen because it has the biggest range on magnitudes.

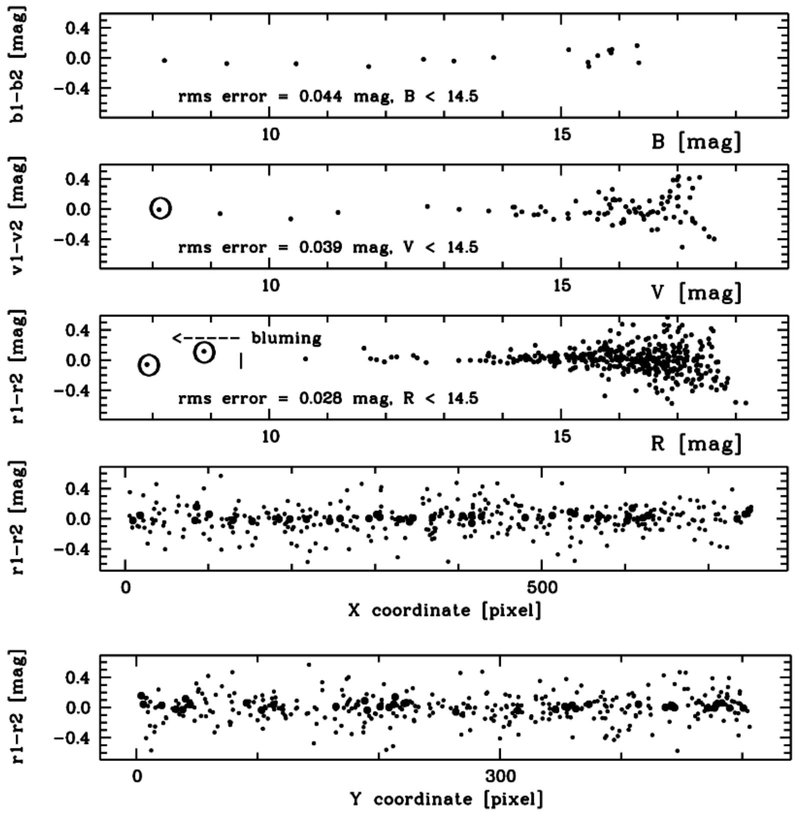

Figure 2. Test of instrumental photometric accuracy of the CCD ST7 camera

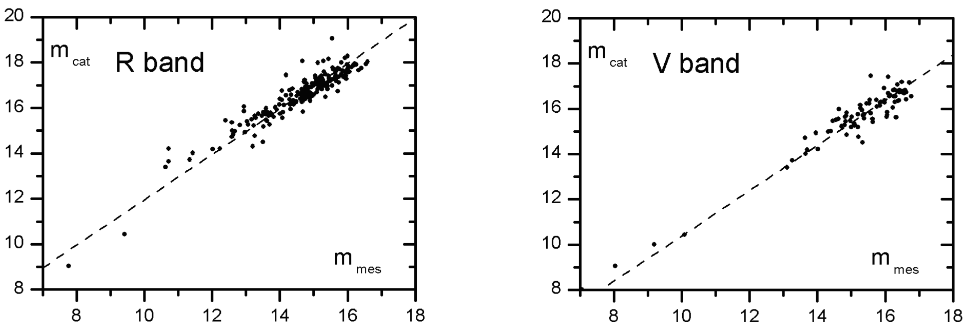

Figure 3. Connection with instrumental magnitudes and magnitudes of the USNO-B catalogue

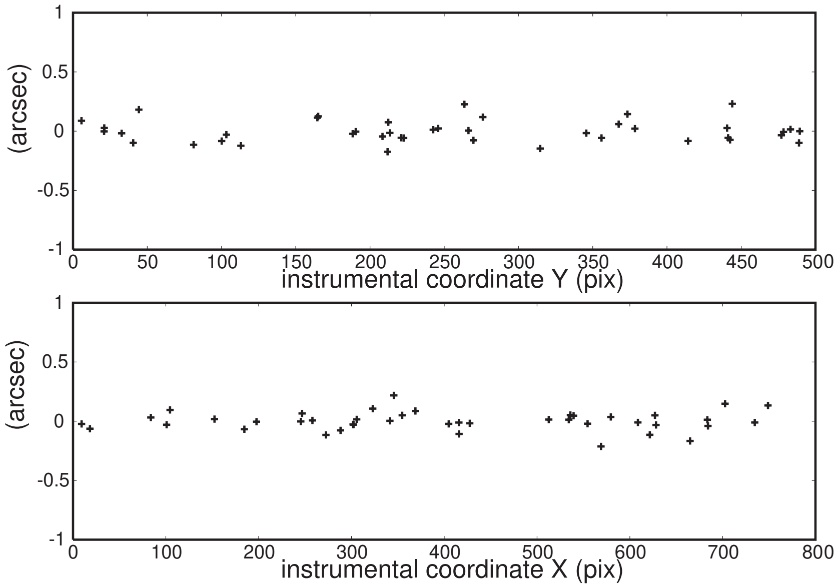

Figure 4. Dependence of a difference between the calculated coordinates and coordinates from the catalogue on rectangular coordinates

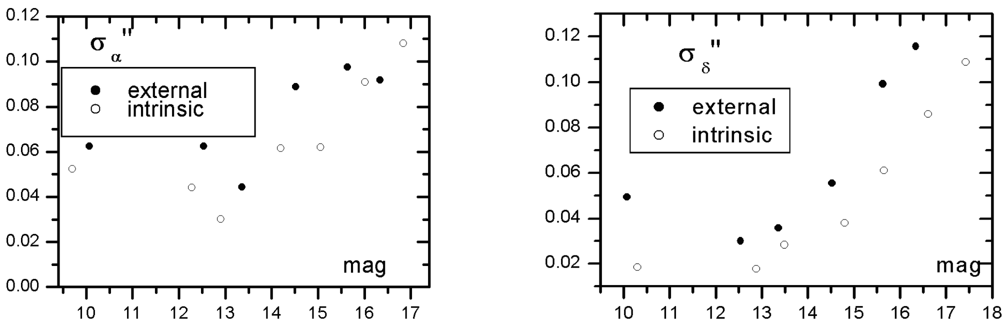

Figure 5. Dependence of accuracy of spherical coordinates on object magnitude

The estimations for limiting star size on the frames were received: 16.2^m for filter B, 18.2^m for filter V, 17.8^m for filter R. Unfortunately, the accuracy of magnitudes in the catalogue is insufficient to investigate differences in photometric systems. The photometric scales are linear within the limits of accuracy of initial data, as shown in Fig. 3.

The UCAC2 catalogue [3] was chosen for research of positional characteristics of the camera. Dependence of a difference between the calculated and catalogue coordinates on rectangular coordinates on the frame is shown in Fig. 4. Regular dependences are not observed here. Mean-square error for all processed stars is equal to $\sigma_\alpha = 0.090$ arcsec and $\sigma_\delta = 0.089''$ for instrumental accuracy and $\sigma_\alpha = 0.095$ arcsec and $\sigma_\delta = 0.094''$ for UCAC2 catalogue. In more details, dependence of coordinates accuracy on object magnitude is shown in Fig. 5. The calculations data shows that the maximum accuracy of measurements is amounted to stars 13^m. For such stars this one is $\sigma_\alpha = 0.028$ arcsec and $\sigma_\delta = 0.021''$ (instrumental accuracy) and $\sigma_\alpha = 0.021$ arcsec and $\sigma_\delta = 0.032''$ (UCAC2 catalogue).

CONCLUSIONS

Photometric and positional accuracy for CCD ST7 camera of the Astronomical Observatory of the Kyiv National Taras Shevchenko University was investigated.

An absence of regular errors in photometry and positions of stars depended upon the position in the frames and star magnitudes were shown on results of these researches.

The accuracy of stars positions obtained with ST7 camera, corresponds to modern accuracy of measurements with CCD cameras.

[1] MIDAS Users Guide, European Southern Observatory – Image Processing Group 1994, Garching, ESO, 1994.– Vol. **A**, **B**, **C**.

[2] *Monet D. G., Levine S. E., Canzian B., et al.* The USNO-B catalog // Astron. J.–2003.–**125**.–P. 984–993.

[3] *Zacharias N., Urban S. E., Zacharias M. I., et al.* The second US Naval Observatory CCD astrograph catalog (UCAC2) // Astron. J.–2004.–**127**.–P. 3043–3059.