Present status of the stellar photometry taken in the RC focus of the 2-m telescope of the Rozhen NAO

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Abstract. This investigation aims to present the state of the stellar photometry derived with the new CCD camera in the RC focus of the 2-m telescope. Both space and color dependencies of the instrumental magnitudes, obtained with the old and new CCD cameras, are demonstrated.

Key words: stellar photometry

Състояние на звездната фотометрия получавана в RC фокуса на 2м телескоп на НАО Рожен

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Това изследване има за цел да представи състоянието на звездната фотометрия, получавана с новата CCD камера в RC фокуса на 2-м телескоп. Показани са двете зависимости на инструменталните величини - позиционната и цветовата, получени със старата и новата CCD камери.

Introduction

In 2006 the CCD camera Photometrics, 1024x1024 pixels, used for direct imaging in the RC focus of the 2-m telescope of the Rozhen National Astronomical Observatory (NAO) was changed with a new one, VersArray, 1340x1300 pixels. For the reason of reliable photometry in the future and the compatibility of the results derived in different periods, we compared photometric results obtained with both devices. The results presented here are based on stellar photometry. For the calibration purposes, the practice of stellar photometry needs the dependencies of the instrumental magnitudes from the inherent characteristics of the system optic-filter-device to be established.

Our experience with the Photometrics CCD showed significant space, as well as color dependence of the instrumental magnitudes. The space dependence (the instrumental magnitudes become weaker towards the center of the field) was already discussed in our previous investigation (Markov [2005]). The reason of this bias feature is beyond the scope of the present study, but we recommend the comprehensive works of Maniford [1995] and Maniford [1996] on this subject to the reader.

In order to perform comparative investigation, appropriate observations of standard fields were obtained with VersArray and newly derived dependencies were drawn.

1 Observations and data acquisition

The observations used in this work were carried out in the RC focus of the 2-m telescope of the Rozhen NAO in 1997 and 1998 with Photometrics and 2007 with VersArray. The observation sets were chosen to reflect the early condition for both CCDs. The standard fields were chosen from the Stetson catalog of standard fields (Stetson [2000]) [1].

[1] http://www3.cadc-ccda.hia-iha.nrc-cnrc.gc.ca/community/STETSON/standards/

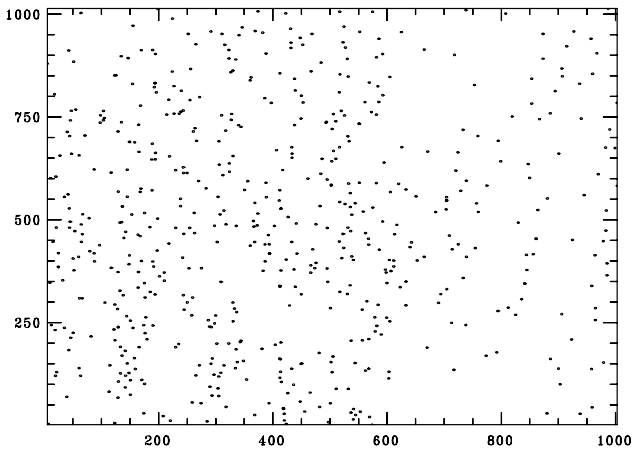

Fig. 1. Space distribution of standard stars over the Photometrics field

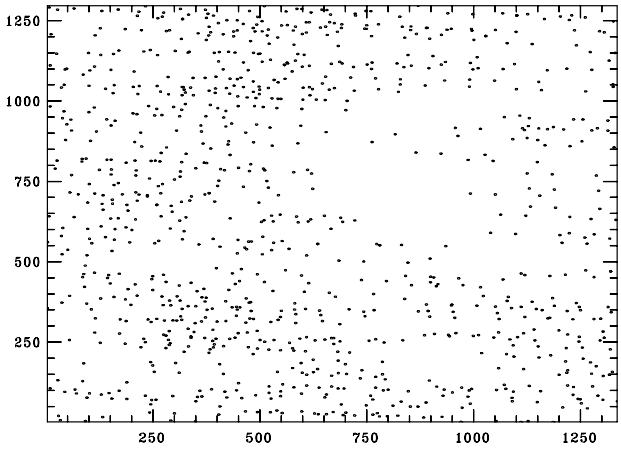

Fig. 2. Space distribution of standard stars over the VersArray field

Two fields with srandards are situated in the region of the globular clusters M2 and M5 and third one is the standard area Ru149. The observations were taken in B and V passbands corresponding to the Johnson photometric system. Consecutive BV sets were taken with telescope coordinates offset between the exposures. Three exposures were taken for every field. In common, there were 9B and 9V images for Photometrics and 3B and 3V for VersArray. The main

goal of this strategy was to ensure more homogeneous distribution of stellar images over the CCD frame using small number of standard fields.

Fig.1 and Fig.2 demonstrate the space distribution of standard stars over the two CCD frames. The abscissa and ordinate axes present columns and rows number of the CCD frame in pixels.

Preliminary frame reduction, PSF stellar photometry and data analyze were performed in IRAF[2] environment supplemented by TABLES. The manner of data arrangement was widely discussed in Markov [2005]. In that article we used polar coordinate system centered on the optical axis of the telescope to investigate the spatial dependence of the instrumental magnitudes. So, in the present work as a first step we found important to check the CCD chip mounting according to the optical axis of the telescope.

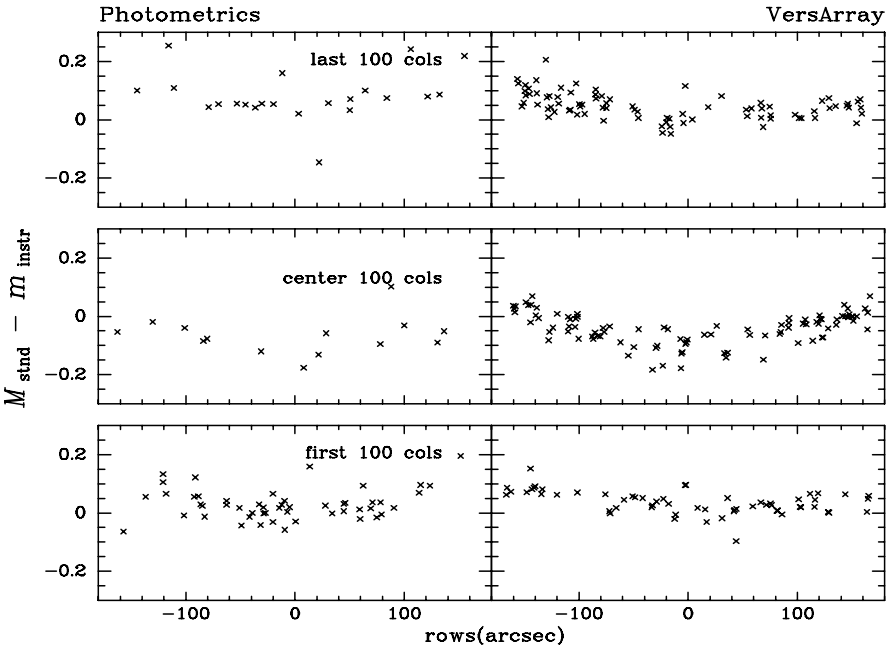

Fig. 3. Space dependence of the instrumental magnitudes along CCD rows

This is demonstrated in the next two figures where the difference 'standard-instrumental' magnitude along rows (Fig.3) and respectively columns (Fig.4) is drawn. The Photometrics' results are shown in the left panels and VersArray's in the right. We like to mention that the two devices have different pixel size and different scale, namely 0.309 arcsec/px for Photometrics and 0.258 arcsec/px for VersArray. In order that the spatially dependencies derived for the two cameras to be comparable we had to use angle instead pixel dimensions of the CCD frame in our presentation. As well, in both figures

[2] IRAF is distributed by the National Optical Astronomy Observatories, which are operated by the Association of Universities for Research in Astronomy, Inc., under cooperative agreement with the National Science Foundation.

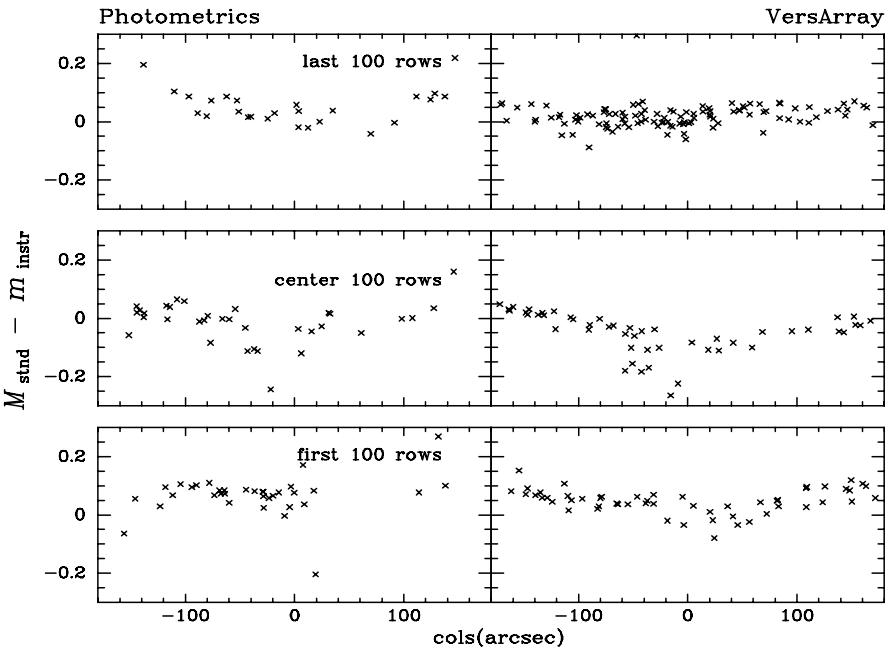

Fig. 4. Space dependence of the instrumental magnitudes along CCD columns

the abscissa presents the stellar image coordinates along rows and columns in arcseconds. The zero point was chosen in the middle of the CCD frame. The three panels in every figure show results concerning the first, the middle and the last 100 rows or columns. In our opinion the two figures show that along the columns the VersArray is slightly offset (20-25 arcsec) the optic axe just in the opposite direction comparatively with the Photometrics mounting. Along the rows the result is more or less puzzling and needs additional observations for more definite conclusions. Nevertheless, an offset of about 10 arcseconds is well detectable. These findings concerning the VersArray results, gave us the reason to state that the center of symmetry of the spatial dependence of the instrumental magnitudes is on [750,690] pixel. For the Photometrics we accept this center to coincide well with the optical one.

Fig.5 shows the radial dependence of the instrumental magnitudes for Photometrics (upper panel) and VersArray (bottom panel). In this figure the differences 'standard-instrumental' magnitudes are drawn vs. the distance of the stellar image (in arcseconds) from the optical axis, as it is discussed above. We derived the respective linear regressions, as follows:

$\Delta m = 0.258 * \sqrt{(X-750)^2 + (Y-690)^2}$ for VersArray and

$\Delta m = 0.309 * \sqrt{(X-512)^2 + (Y-512)^2}$ for Photometrics.

Here X and Y are the stellar image centroid coordinates according to the CCD frame, in pixels.

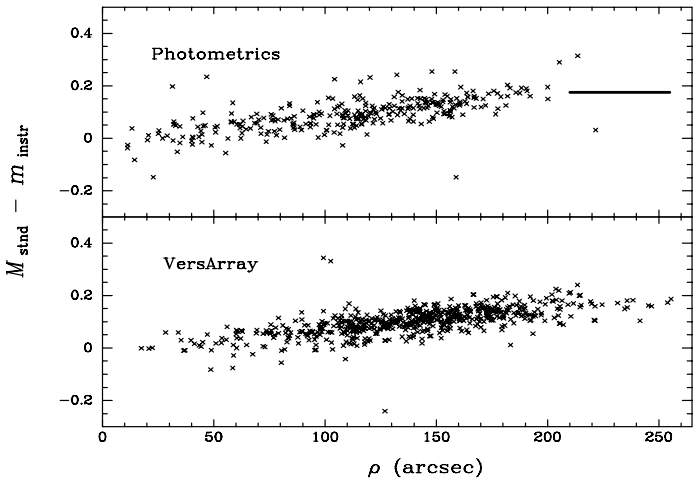

Fig. 5. Radial dependence of the instrumental magnitudes

Fig.5 shows clearly that the radial dependence was not changed at the new mounting. Therefore, we can conclude that the space dependence is connected most probably with the optical assembly of the telescope and this result is not surprising. We would like to draw attention also to the less steeper gradient of the dependence in the central and peripheral regions of the frame. This is especially well pronounced in the data taken with VersArray whose quality is better. An conclusion could be drawn that the spatial dependence rapidly drops (and even vanished) somewhere on 210-220 arcsec from the optical center. In the next observations we have to increase the number of standard stars appeared in these regions in order to establish the intrinsic tendency of the spatial dependence of the instrumental magnitudes. These regions are not reachable with the Photometrics data because of the less dimensions of the camera. In the Fig.5 (upper panel) this region is marked with a bold line. We hope this finding to help us to establish the true nature of this optic feature.

Here we like to alert that in Markov [2005] a transformation coefficient wrapped with the old CCD camera dimensions was proposed. If somebody keeps to follow that manner of calibration an attention has to be paid and the coefficient stated in Markov [2005] should be reestablished because of the different spatial scale inherent for VersArray

An important relation used for calibration purposes is the color dependence of the instrumental magnitudes. These dependences, for both cameras, are demonstrated in Fig.6 and Fig.7 for B and V passbands respectively.

In both figures, the abscissa presents $B-V$ color index for standard stars, the ordinate is the difference 'standard-instrumental' magnitude. In our opinion the color dependencies in both passbands are more prominent for the new camera (VersArray). For this camera the color dependence in B for the red stars is steeper. In the first order both dependencies could be approached with a straight line.

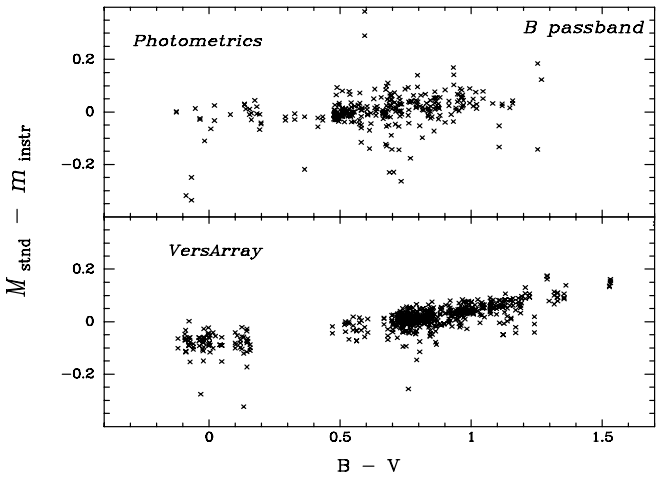

Fig. 6. Observed color dependence in B passband

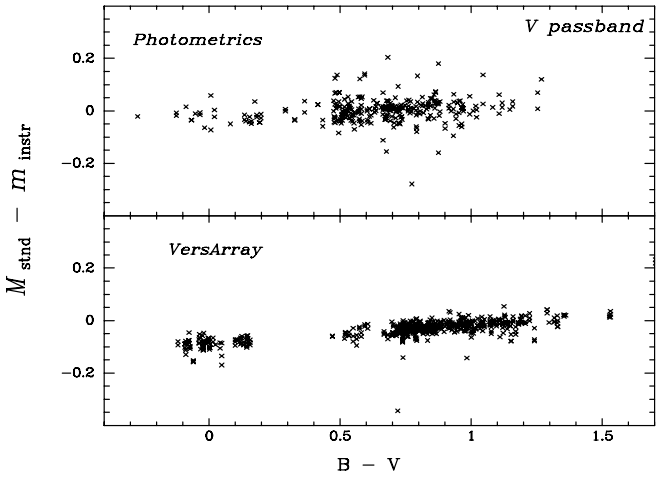

Fig. 7. Observed color dependence in V passband

Conclusions

The new VersArray CCD camera in the RC focus of the NAO 2-m telescope does not provoke dramatic changes in the photometric conditions. Calibrating stellar photometry taken with VersArray one has to account: a) Different color dependencies in the B and V passbands; b) The spatial correction should be prepared with care taking in account the smaller pixel size of the new camera. More sophisticated transformations have to be applied to account the spatial dependence of the instrumental magnitudes.

The topology of the spatial dependence should be analyzed thoroughly in order to clarify its nature.

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