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PROGRESS IN SUPPRESSING SCATTERED LIGHT INTO THE OPTICAL BEAM PATH OF THE NAO ROZHEN 2 M TELESCOPE

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Abstract. In this poster paper we present a summary of the published analysis of the spatial dependence of the magnitudes derived from images obtained in the RC focal plane of the 2 m RCC NAO Rozhen telescope. An alert for the possible reason was the unusually curved flat-field images taken as a part of the standard CCD calibration procedure. The reasons for the problem are described and a solution is presented, which consists modification of the mirror baffles and mounting of special diaphragm at the entrance of the filter wheel.

1. INTRODUCTION

The presence of scattered light in the optical beam path in telescopes is a serious problem. One of the main elements for a good photometry is the reliability of the flat-fields. The flat-fields themselves are obtained in strong highlightning on sky or on dome-screen. If circumstances for scattering of the light appear in the telescope tube, the fields are centre–illuminated. In this case the flat-fielding introduces more errors in the bidimentional photometry and it is not usable, unless some spatial corrections (Markov 2005a) are done. The best solution is to eliminate the scattered light. It can be done by the mounting of rings (annuli) inserted in the mirror baffles (Grundahl and Sorensen 1996) or with special diaphragms (see Section 3).

This paper concentrates on our efforts to improve the photometry, obtained in the direct focus of the 2 m Ritchey-Chretien-Coude (RCC) telescope at the National Astronomical Observatory (NAO) Rozhen. All of the observations in this paper are carried out with the CCD camera VersArray 1300B. Its field of view in the direct focus of the telescope is 5.76 x 5.59 $arcmin^2$. Data reduction and photometry are performed with the use of standard IRAF routines.

2. THE SPATIAL DEPENDENCE – SUMMARY

The spatial dependence of the photometry, found in the images (Fig. 1 – left panel), taken with the 2m RCC Rozhen telescope, is described for the first time in 2005

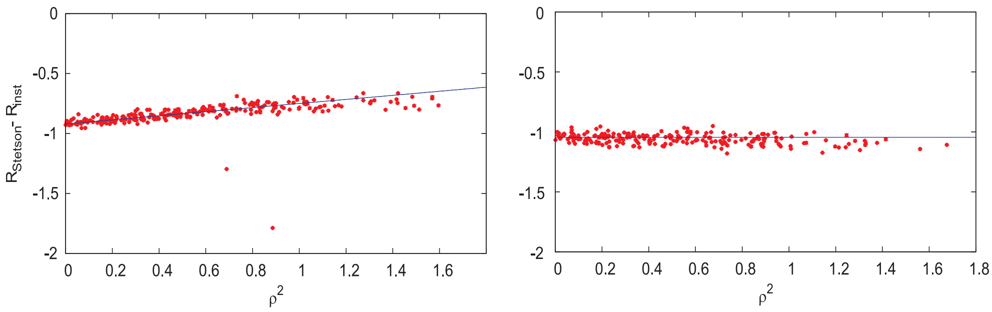

Figure 1: The difference $R_{Stetson} - R_{inst}$ magnitudes for the stars in the field of NGC 7790. The left panel is derived from image, obtained on 2008 October 07 and the right one is from image, obtained on 2009 July 18, after the diaphragm mounting (see Section 3).

(Markov 2005a, 2005b). The problem is not inherent for the photometry results (Ovcharov et al. 2008) taken with the focal reducer (Jockers et al. 2000), used in the same focal plane. This leads us to the conclusion that this phenomenon is bounded with the design of the CCD camera holder itself. We plan to postpone the discussion about its origin for a further work. We adopted an approach suggested by Markov (2005a) to introduce a radial dependent term in the transformation equation as a temporary phenomenological method to transform the instrumental magnitudes close to the standard ones.

3. SOLUTION OF THE PROBLEM

In the last few years the more detailed analysis of the spatial flux variations gradually allowed to reveal the reasons for them. Therefore the method of a pinhole camera (camera obscura) was realized. The pinhole mask was placed in front of the filter wheel. Exposing the CCD in this configuration gives an image of the light sources in the optical path. The left panel in Fig. 2 shows the pinhole image, obtained on 2009 April 02. The light rings on it show the light, scattered from different areas in the telescope tube. In order to reduce the inside tube reflection light we calculated the diameters of 7 separated blends in such a way that in the focal plane of the telescope we have a free vignetting circle area with a diameter of 200 mm. The blends are aluminium rings with sharpened inner edges and were installed at the inside of the primary mirror baffle (Fig. 3). The results after the baffle modification are shown in the right panel in Fig. 2.

The results demonstrated on Fig. 2 show that blending the interior of the primary mirror baffle gives good results. Nevertheless, some additional effort should be done to completely solve the problem with the scattered light inside the telescope design. Hence, baffle modifications do not change the appearance of the flat fields themselves, which remains the same since scattered light is not the main source for flat fields distortion. To clarify the problem at that stage of our investigation we performed a statistic analyze of the flat fields which reveals a non-Gaussian distribution with two peaks (see Fig. 4).

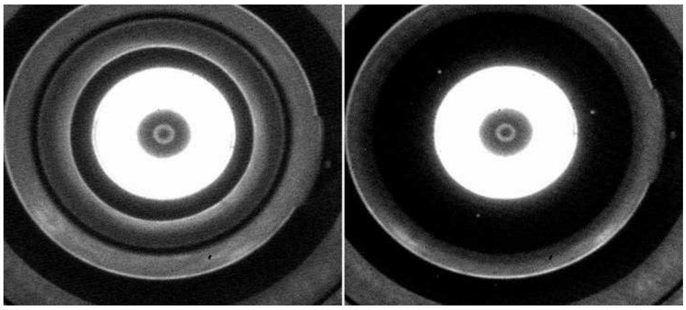

Figure 2: Left: A pinhole image, obtained on 2009 April 02; Right: A pinhole image, obtained on 2009 April 17, after the baffle modification.

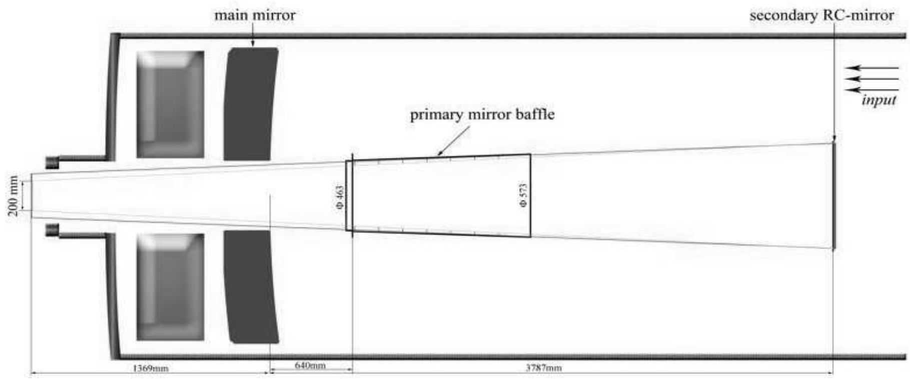

Figure 3: A telescope sketch and sense of the light beam inside of the tube.

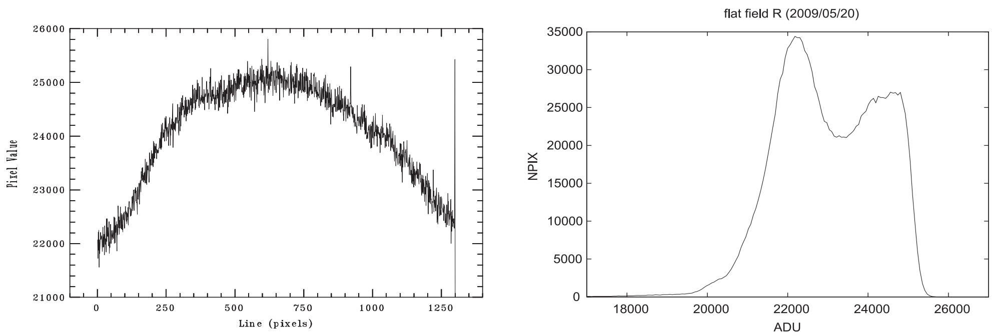

Figure 4: The left panel shows the pixel line from flat-field in R-band, obtained on 2009 May 20. The right panel is the histogram of the flat-field.

Experiments for clarify the reason of these peculiarities were done. One of them was to obtain flat-fields without filter. The histogram of the flat-field, obtained through the empty hole of the filter wheel has the same appearance as if it is obtained with filter. When the filter wheel is removed the flat-field histogram has Gaussian shape.

These experiments suggest that the reason for the wideness and the second peak on the flat-field's histogram is the presence of reflections on the filter wheel, although it is black painted.

To suppress these reflections a diaphragm with diameter of 40 mm (Ovcharov et al. 2009), slightly smaller than the filter itself, is mounted in front of the filter wheel. Fig. 5 shows the R-band flat-field, obtained after the diaphragm mounting.

For confidence we obtained a standard field (Stetson 2000) and made test for spatial dependence of the flux (the right panel in Fig. 1).

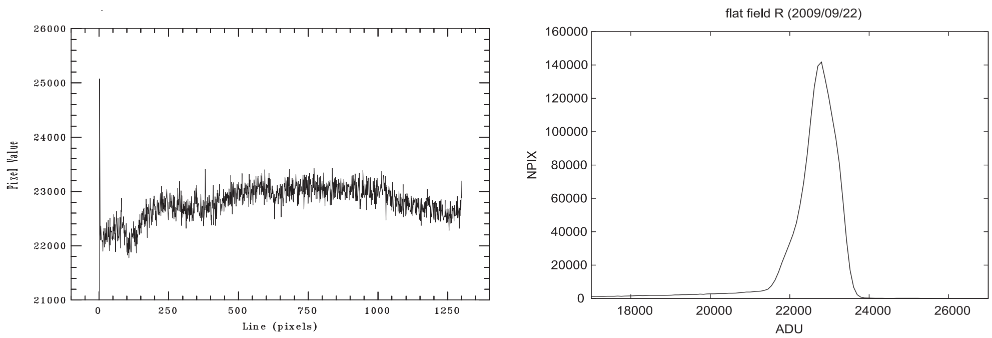

Figure 5: The same as Fig. 4 but obtained on 2009 September 22 after the diaphragm mounting.

4. CONCLUSION

This work summarizes all published works for the spatial flux variations in the field of the direct focus of the 2 m RCC NAO Rozhen telescope. Determination of the reason for the presence of scattered light into the optical beam path of the telescope and considerable progress in the suppression of the reflections in the telescope tube are described. The research on the removal of the reflections into the telescope tube is still in progress. More baffle modifications and new constructive solution for the filter wheel will be done and a larger size filters will be used.

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