Current status of the optic alignment of the 2m Rozhen telescope

Haralambi Markov, Pencho Markishki, Tanyu Bonev
Institute of Astronomy and Rozhen NAO, Bulgariam Academy of Sciences
hmarkov@astro.bas.bg, markishky@mail.bg, tbonev@astro.bas.bg

(Conference talk)

Abstract. The two hyperbolic mirrors design of a Ritchey-Chretien (RC) optical system is characterized as a system free from coma, astigmatism and spheric aberrations. By definition, the RC telescopes offers high quality images over a large field of view. In order to optimally utilize the advantages of a RC telescope, its optic should be perfectly collimated with a checking of the mutual disposal of the optical elements. In this article we present the steps we followed to establish the current status of the 2-meter Ritchey-Chretien-Coude NAO Rozhen telescope optic alignment after the recoat of its mirrors. We consider the normal status of the telescope is restored.

Key words: optic: collimation:

Състояние на оптиката на 2-м телескоп на НАО - Рожен

Хараламби Марков, Пенчо Маркишки, Таню Бонев

Ritchey-Chretien (RC) оптичната система на 2-м телескоп на Националната астрономическа обсерватория (НАО) "Рожен" се характеризира като система свободна от кома, астигматизъм и сферична аберация. По определение RC телескопите показват изображение с високо качество върху голямо поле. За да се използват пълноценно възможностите на тези телескопи е необходимо регулярно да се извършва т.н. колимация. Това е процедура, в която се проверява взаимното разположение на оптичните елементи. В статията е описано изследването на настоящето състояние на оптиката на 2-м телескоп след процесите на демонтаж и монтаж на главното огледало, както и на първото диагонално плоско огледало, захранващо Куде фокуса, свързани с поредното възстановяване на алуминиевото им покритие. Ние смятаме, че работното състояние на телескопа е напълно възстановено.

1 Introduction

All telescopes have to recoat their mirrors every few years in order to keep good reflecting condition of their surfaces. This procedure includes mandatory dismounting and subsequent assembly of the telescope optical components. The procedure ends with a collimation test which aims to show if the optical components are brought back into line. In the summer of 2008 the main mirror as well as the first diagonal Coude mirror of the 2m telescope of the RAO went through an alluminization procedure. After the assembling of the optical system, in the middle of September, we performed some tests aiming to prove the current state of the telescope optical alignment. In the optical practice this is called collimation.

Collimation is the adjustment of the alignment of each optical element of the telescope with regard to the others. Practically in the Cassegrain telescopes, all the optical elements should be perfectly aligned to a common axis. The collimation is a way of improving the performance of a telescope considerably. No acceptable result can be achieved at high resolution without an irreproachable collimation. Image processing is incapable of compensating for the damages caused by a misalignment. Lack of collimation results in asymmetric stellar images which could not be properly focused (http://legault.club.fr/collim.html)

In order to check the status of the optic alignment of the 2m telescope we followed the principles of optical design described in Mihelson [1976] and Artus [2006]. In the next Section 2 we outline the main steps performed in our investigation. Results are commented in Section 3.

2 Collimation tests and results

Following Artus [2006] the geometrical axis of the telescope tube is a fundamental axis of symmetry according to which the optical elements should be arranged. For a proper telescope collimation both mirrors should be aligned with that reference axis and their centers should lie on it. The most common misalignment cases are considered in fig. 1: a) one of the mirrors is shifted according to the fundamental axis but both mirrors' axes are parallel; the mirrors' centers lie on the fundamental axis but: b) the main mirror is tilted, c) the secondary mirror is tilted; d) both mirrors are tilted.

At this stage of our investigation we are not prepared to test the main mirror orientation and we accepted with caution its position as proper. Therefore our experiments and measurements are dealing with the secondary mirror position and orientation.

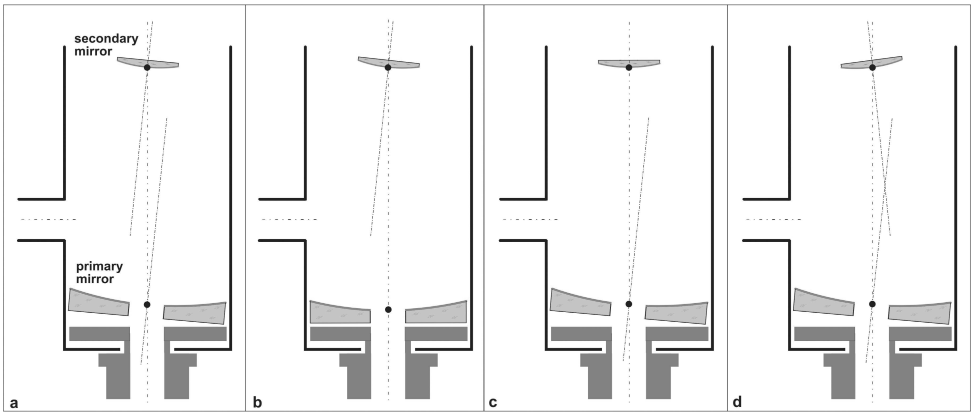

Fig. 1. Possible cases of misalignment of the telescope optic.

The collimation tests were performed with the use of an autocollimator the principal scheme of which is shown in fig. 2. Every autocollimator projects a beam of collimated light. It measures the deviation between the emitted beam and the reflected beam. The registered displacement is a measure for small angles in the object space under consideration. In practice we measure the displacement between the centers of two reticles - the eyepiece one (duplex cross in our case) and and the reflected one (Siemens star in our case).

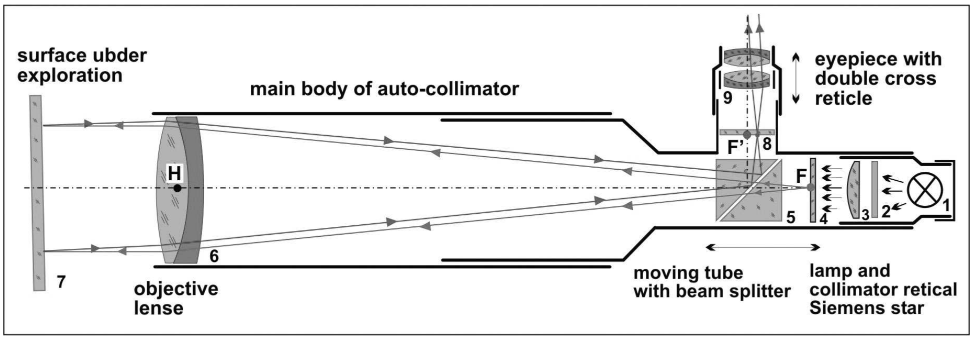

Fig. 2. The auto-collimator principle scheme.

To test the collimation we used to position the telescope to the zenith and placed the autocollimator horizontally on the floor under the bottom of the telescope tube. The output beam was directed into the tube with a flat mirror. Figure 3 presents the principle scheme of the telescope optic arrangement and the positions of all additional tools used.

The first step was to find at least two points which lie on the fundamental axis and this way to define it in practice. For this reason the centers of two characteristic planes in the telescope design were selected: namely, the center of the first diagonal Coude mirror holder(point K1 on fig. 3) and the center of the offset module(point K2 on the same figure). The latter one is the place where the detector is mounted. To mark out the selected points with a confidence three armed fiber cross reticles were arranged. Fibres were tauten between diametrically placed bolts with a small steel springs(fig. 4). Using the autocollimator focusing we are able to see consequently the direct and the reflected(from the secondary mirror) images of K1 and K2 points. If the optical axis of the secondary mirror does not coincide with the reference axis, this would cause a displacement between the direct and the reflected image. The value of this displacement is a measure for the deviation of the secondary mirror from its nominal orientation. As a first step the centers of the autocollimator eyepiece and the cross reticles placed at K1 and K2 should be aligned ensuring the autocollimator to be colinear with the fundamental axis. After that we are prepared to check the positions of the mirrors according to this axis. Note that this approach relies on the presumption that K1 and K2 are well centered according to the telescope tube.

Because of unproper characteristics of the available autocollimator we did not achieve satisfactory direct focusing on the reticle in point K2 and actually

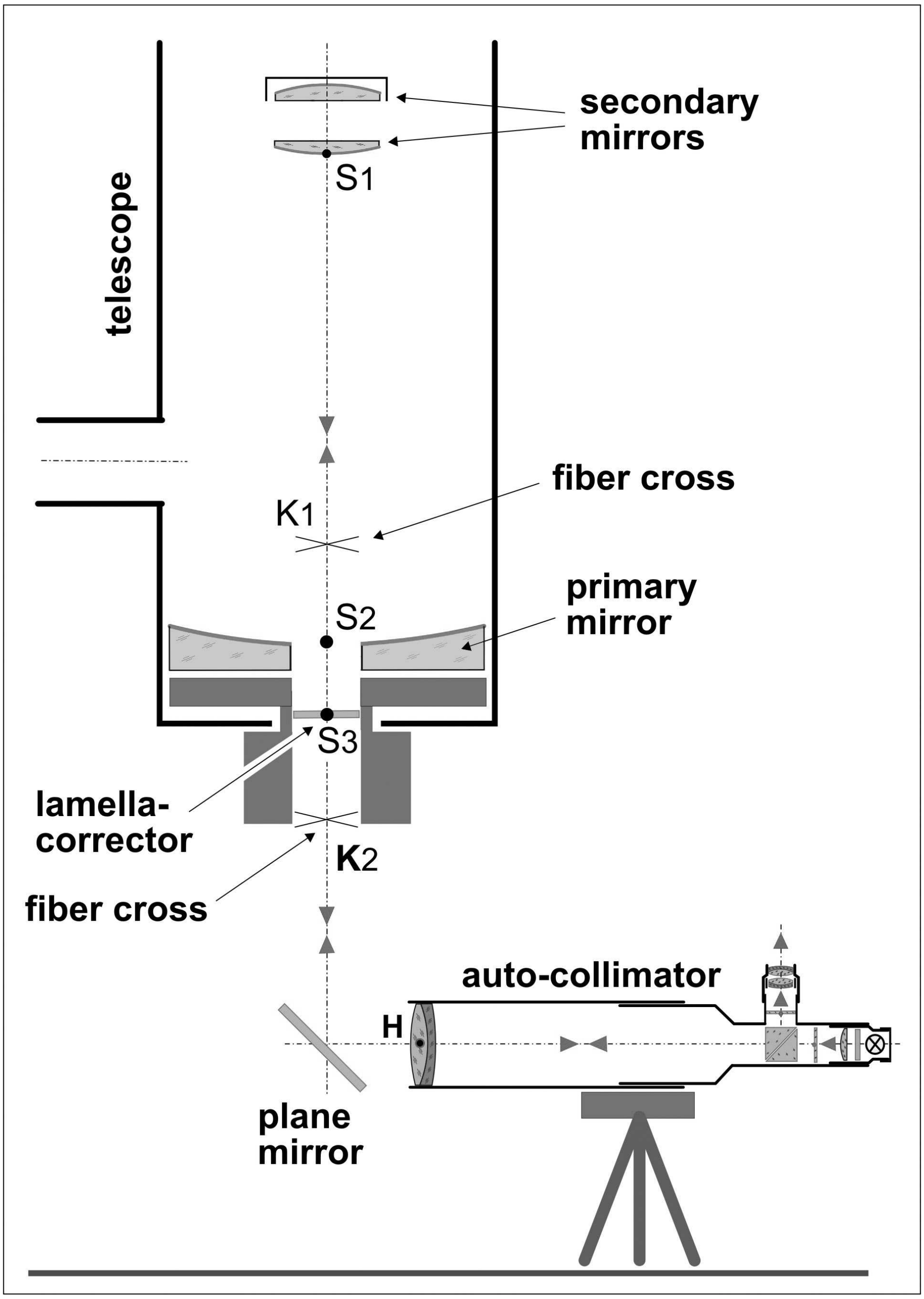

Fig. 3. The working scheme.

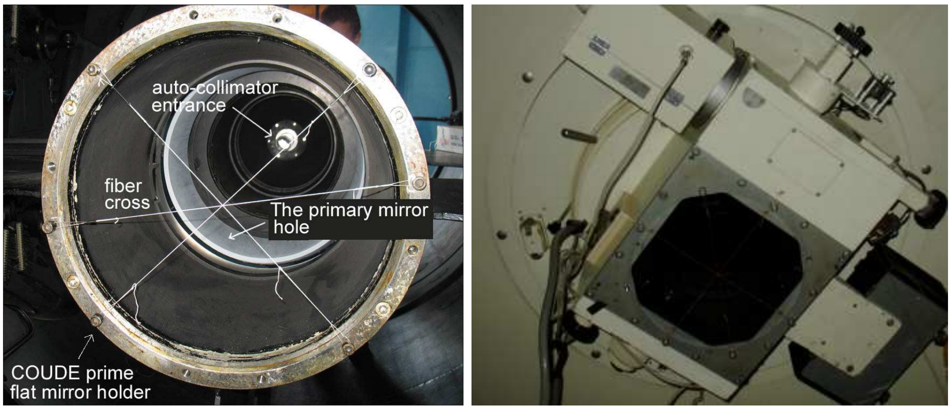

Fig. 4. The fiber cross reticles design and their actual places. This figure shows detailed view of the places of point K1 (left) and point K2 (right).

the test was performed with one reference point. In this case the reason for the observed displacement(if any) could be twofold. It could be caused by either the tilt of the secondary mirror, or its radial displacement. This is well illustrated in figure 5.

Actually we used another characteristic point assuming it lies on the fundamental axis described above. Such point is the cross mark in the center of the secondary mirror. The secondary mirror was not removed from the telescope during the re-alluminization campaign and this circumstance justifies the assumption that its center should lie on the reference axis. To check this, the autocollimator was focused on the center of the secondary mirror(cross marked). Then moving the autocollimator horizontally according to the telescope bottom, we achieved to align the centers of the eyepiece, the secondary mirror and the Siemens star image. Fig. 6(a) shows a snapshot of this result.

In the next step the autocollimator was consequently focused directly on K1 point and on its reflected image. Within the errors of the autocollimator positioning the directly focused K1 point coincided with its reflected image as well as with the eyepiece reticle and the Siemens star centers(see Fig. 6(b)). Additionally we have observed the reflected K2 image also projected close to these points. These results could be concerned as evidence that the secondary mirror is not dramatically shifted neither tilted according to the fundamental axis. The biggest observed angular displacement of the centers of these images and the Siemens star center was evaluated at less than 50 arsec. This corresponds to about less than 2 mm deviation from the fundamental axis. Once again we have to remind that this is true in the presumption that K1 lies on the tube axis

In the last test we did concern with the orientation of the plane where the CCD camera is mounted during observations - actually this is the place were point K2 was selected (fig. 4, right). To check this we fixed a reflective surface on this plane and looked at the Siemens star image at different position angles of the offset module. For this reason we put together the two centers (namely

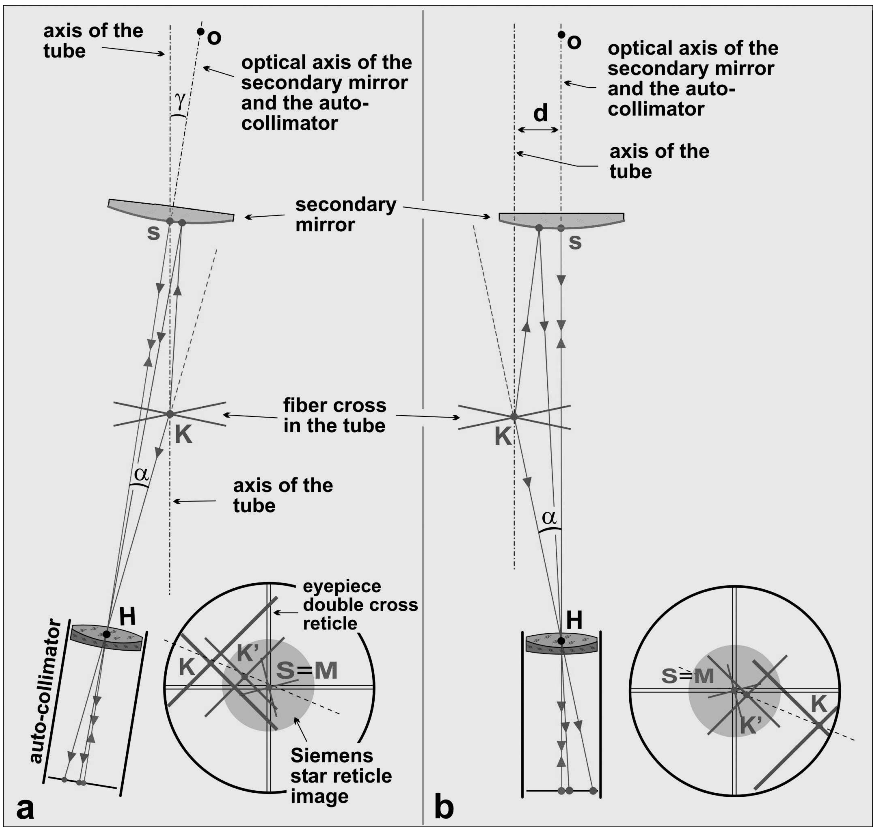

Fig. 5. This figure demonstrates the twofold reason for the observed displacement.

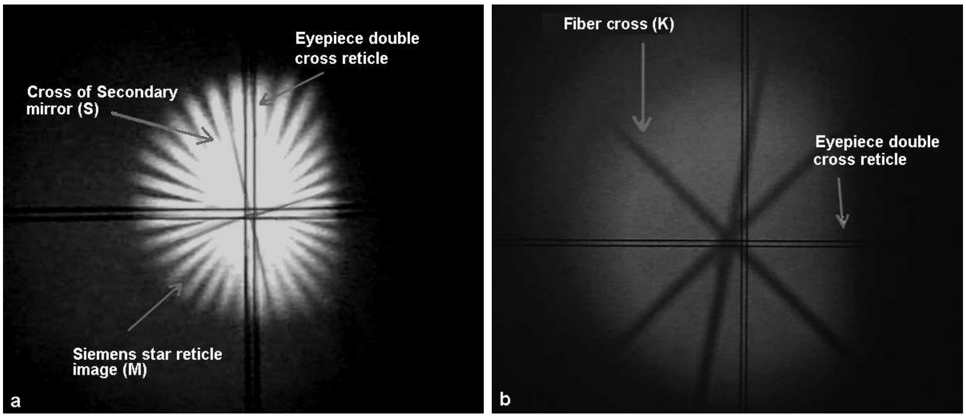

Fig. 6. Results of the secondary mirror settlement.

the eyepiece and Siemens star reticle centers) then rotated the position angle at 180 degree and registered the displacement between the two centers. The displacement was assessed at 4.6 arcmin. We consider an inclination of the rear plane of the offset module as a possible reason for this displacement.

3 Comments and some conclusions

We have to point out that the performed tests did not concern the position of the main mirror.

Concerning the secondary mirror, within the errors of the autocollimator positioning, we accept the arrangement of this mirror as satisfactory and could not register any dramatic misalignment of this optical component.

The most valuable result in our tests is the detected inclination of the plane at which the detector of light in the RC focus is mounted. Our next tests did show that this is not connected with the rearrangement of the telescope optic and has its own original nature which should be thoroughly examined in the future.

Taking into account that the disassembly and assembly of the 2-m optical system was done for the first time by a Bulgarian team, without supervisors from the telescope producer company we find that the current condition of the telescope resembles its previous state satisfactory. A more complex analysis of the optical system status, based on Hartmann tests, will be performed during the next technical nights.

Acknowledgments:. This investigation was partly supported by the grants NIK-05 and DO 02-85 with the National Science Fund of Bulgaria.

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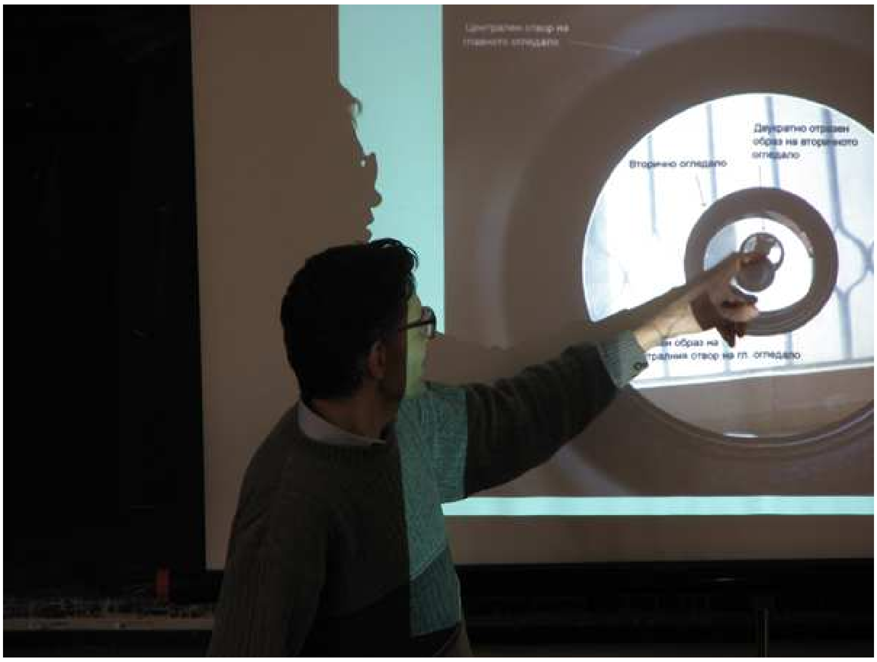
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