RC OPTICAL SYSTEMS TECH SHEET

Ritchey-Chrétien Alignment & Collimation

Authored by John Smith exclusively for RC Optical Systems

Introduction

In order to obtain optimum performance from a Ritchey-Chrétien design, the primary and secondary mirrors must have their optical axes aligned with each other such that the optical axis of one mirror lies along that of the other. This is called collimation. Additionally, some optics sets require a rotational alignment (indexing) between the primary and secondary mirrors. Stan Moore has developed an excellent collimation methodology using the Takahashi collimation telescope in concert with a dot in the center of the secondary mirror that is highly recommended and quite successful. It is summarized on the RC Optical Systems web site at: http://www.rcopticalsystems.com/collimation.html. Stan's method is incorporated into this alignment procedure.

Tools

The following tools are needed to perform this alignment:

- Takahashi Collimating Telescope
- Tak-2-AP adapter or T-2-AP adapter from RCOS
- Allen wrenches (T-handle preferred)
- Small flashlight
- Laser collimator (optional)

Note that T-handle Allen wrenches provide more precise control and allow a screw to be tightened securely without introducing a bending or twisting force on the assembly being tightened.

Indexing (if required)

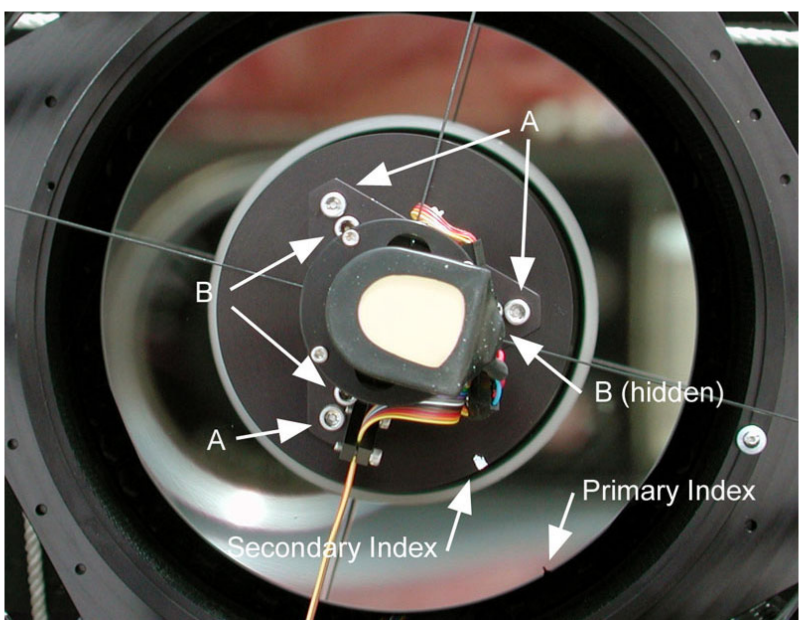

Figure 1: Front View

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Refer to Figure 1, above. Looking in the scope from front, you should see a white dot on the back of the secondary mirror assembly. This is the secondary index. Looking at the primary, you should see a black mark on the edge of the mirror. This is the primary index. (If you do not have these index marks, then your optics do not require indexing.) Now locate your eye approximately in the center of the telescope from the secondary end. Keeping your eye close to the center, move closer to or further from the scope until you can see the primary mirror mark close to the secondary mirror mark. When the perceived size of the secondary is close to the size of the primary, you will see the two marks very close to each other and can best judge the primary alignment.

If the mirrors are not rotationally aligned, you need to rotate the primary mirror so that the two index marks are very close to each other rotationally. The primary is held in position by a locking collar, which secures the mirror snugly. You can rotate the mirror without excessive force. The object is to get the primary index and secondary index rotationally aligned by rotating the primary. For the truss model, you can reach in and rotate the primary and review the alignment. For the closed tube model, you need to remove the back plate, rotate the primary, secure the back plate and review the alignment. Do not touch the front surface of the mirror as finger oils can damage the coatings. After you have rotated the primary mirror, check the indexing again as described above. You should try to get this as close as you can.

Collimation

Collimation is done in two parts – in daylight and then with a star test. The more precise the daylight alignment, the easier the star test adjustments will be, if needed at all. The star test is always a good check on collimation to see if anything has changed significantly.

The secondary mirror has a dot in the center. This dot is very precisely located to define the mirror center. To distinguish it from other reference marks, it is called a “blot” (contraction of “black dot”). It is not completely black but has an appearance as if drawn by a felt pen (it was!) This blot is the key to successful alignment. Before proceeding, look at the secondary through the back of the telescope to see this blot and note its appearance. It is important to identify its texture, as this will be a good visual cue later in the collimation process

1. Daylight Alignment

Collimation is best done with a Takahashi Collimating Telescope and an adapter, which mates this scope to the 2.7” extension tubes. Additionally a suitable measuring tool is useful for checking the spider centering. Using the long end of an Allen wrench of the appropriate size as a feeler gauge can work equally well. The Optical Tube Assembly (OTA) should be horizontal to minimize the possibility of dropping tools on the primary. Also, the OTA should be pointed at a flat illumination. This can be the sky, a sheet hung up a short distance away, or any relatively uniform illumination source. Also, before beginning, be sure the secondary mirror position is set as close to the spider assembly as possible, i.e., as far from the primary mirror as possible. This is the home position on the Telescope Command Center (TCC) or, if you have the RoboFocus set up properly, it should be close to the zero position.

1.1 Spider Centering

At each of the four spider mounting points, note that there is a gap between the secondary support ring and the spider rib. The spider is under tension by the four screws that mount it to the secondary support ring. The four gaps should be as equal as possible, say within an Allen wrench size (.016”). To adjust these gaps if necessary, tighten one screw and loosen the opposite one until they are equal. See what Allen wrench fits snugly into a gap and adjust the others similarly. Check the pair at right angles to the first pair and adjust them if necessary. Check all four gaps after adjustment and repeat if necessary. This is a reasonably precise way to achieve secondary centering with the camera axis.

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Another and perhaps better way to do this adjustment is to insert a laser collimator in the 2” eyepiece adapter. It is important to insure the laser is bore sighted accurately by rotating the laser in the 2” holder, locking it down every 90 degrees or so and noting the position of the laser dot on the secondary mirror. Observe all laser cautions if you try this. If the position of the laser relative to the blot is consistent as you rotate the laser collimator in the holder, then it may be used to center the secondary mirror. If not, then you must determine an “average center position” for the laser and adjust the secondary spider to that position. Once the laser collimator bore sight accuracy is established, you should see an image as shown below.

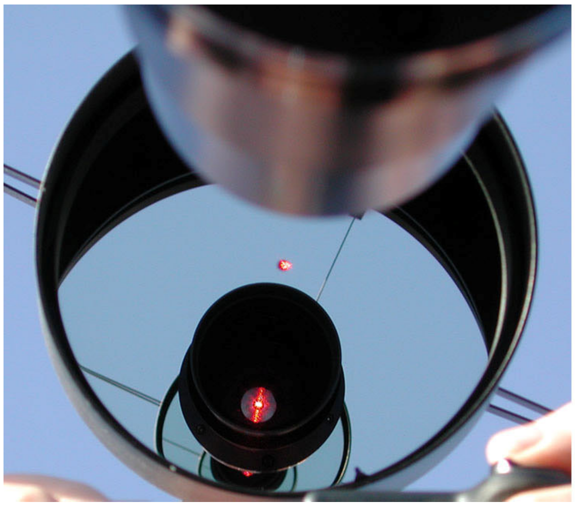


Figure 2

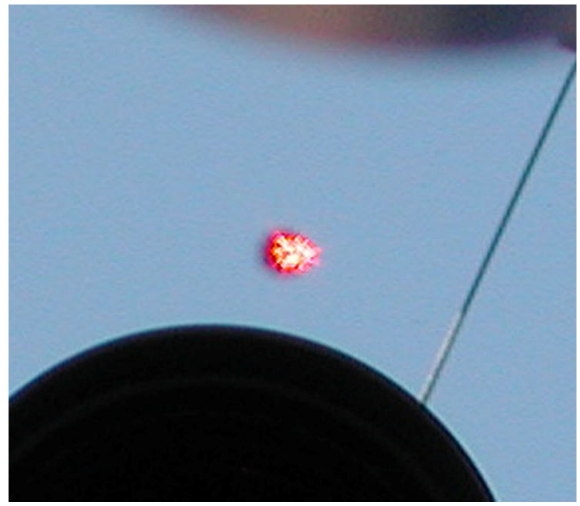


Figure 3

Figure 2 is a photo of the front of the scope. The red light towards the bottom is the laser light emanating from the back of the scope and through the primary baffle. The small red dot at the center is the laser beam landing on the secondary mirror. Figure 3 is a close-up of the red laser dot landing on the secondary blot. The laser is very slightly to the right of the center of the blot. This represents very good alignment and was achieved by the gap measurement method. Again, a laser collimator is not necessary. However, if you happen to have a laser collimator with good centration, it can be used effectively.

1.2 Secondary Mirror Tip-Tilt

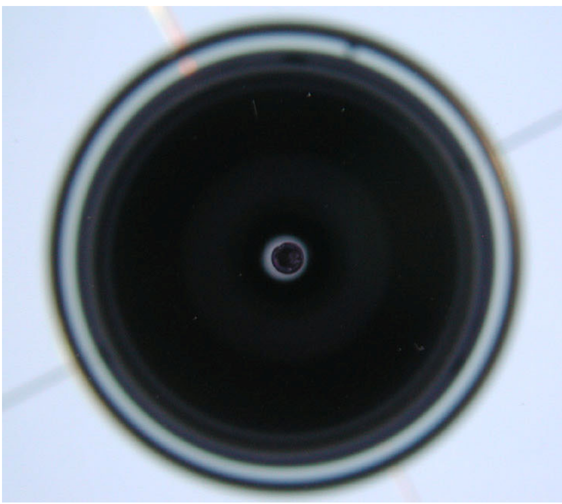
This step adjusts secondary de-centering to the viewing axis more precisely, albeit via tip/tilt adjustments. Again refer to Figure 1. Looking at the secondary assembly, you will note three sets of two screws spaced 120 degrees around the assembly. The outer three are labeled “A” in Figure 1 and are the “pull adjustments” – they pull the secondary toward the mounting plate. The inner three, labeled “B” in Figure 1 are “push adjustments” – they push against the secondary mounting plate to the degree the pull adjustments allow and lock the secondary mounting plate. The push adjustments are essentially locking screws.

If the telescope has been shipped uncollimated (14.5” and larger), the pull adjusters are fully clockwise. You need to loosen these to get some adjustment range. After mounting the mirror, unscrew each of the three adjusters equally around 1.5 to 2 turns. The push adjusters will now be loose and no longer contacting the mirror mounting plate.

Screw all the 2.7” extension tubes that came with your telescope together and screw them into the Fixed Instrument Adapter (FIA) plate. (If you do not have the Fixed Instrument Adapter, extend the draw tube all the way out and add any 2.7” extension tubes you may have. If the Takahashi collimating scope is not extended far enough from the back plate, you may not see the light annulus, as shown in Figure 5.) Look through the back plate and observe the blot in the center of the secondary mirror. This blot should be close to the center of the extension tube. If not, adjust the pull adjusters until it is. This step roughly aligns the optical axis of the secondary to the extension tube/instrument axis.

Now, thread in the Tak-2-AP adapter and then the Takahashi collimation telescope into the adapter. Note that the Takahashi scope has a white frosted area partway down the scope. This is a diffuser that can be illuminated with a flashlight to make the secondary dot more distinct.

Note that the Takahashi scope uses a sliding action for focusing. Start with the sliding all the way in. While looking in the Takahashi scope, slowly slide to tube out while keeping a flashlight on the diffuser. Eventually you will see the blot come into sharp focus. It may or may not be in the center of the illuminated area. Continue to slide the tube out and then another dot will come into sharp focus. This is the outline of the end of the Takahashi collimating scope. Slide the tube back in to refocus the blot. Ignore any other light and dark patterns for the moment. The goal of adjusting the secondary is to get the blot centered on the Takahashi collimating scope dot. Do not be concerned with the centering of the blot in the light area. The goal is to get the blot and the dot on top of each other.



Figure

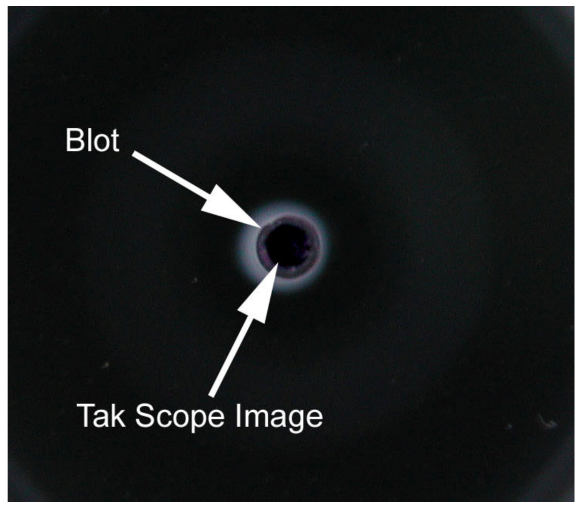


Figure 5

Figure 4 is an image taken through the Takahashi scope. Figure 5 is a blow-up of that image. Note the blot (secondary dot) is less dark than the image of the Takahashi scope, the latter being better defined. This image shows the blot and the dot being very well centered. When you begin, the blot will most likely be well off the center.

This adjustment is done by trial and error adjustment of the pull screws to center the secondary dot. As you get close, it is helpful to focus the Takahashi scope alternately on the dot and the ring to fine-tune your centering. Once this is close, snug up the push screws but do not over tighten them. Check centering after doing this and make smaller adjustments if necessary by loosening the push screw and tightening the pull screws.

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1.3 Primary Mirror Tip-Tilt

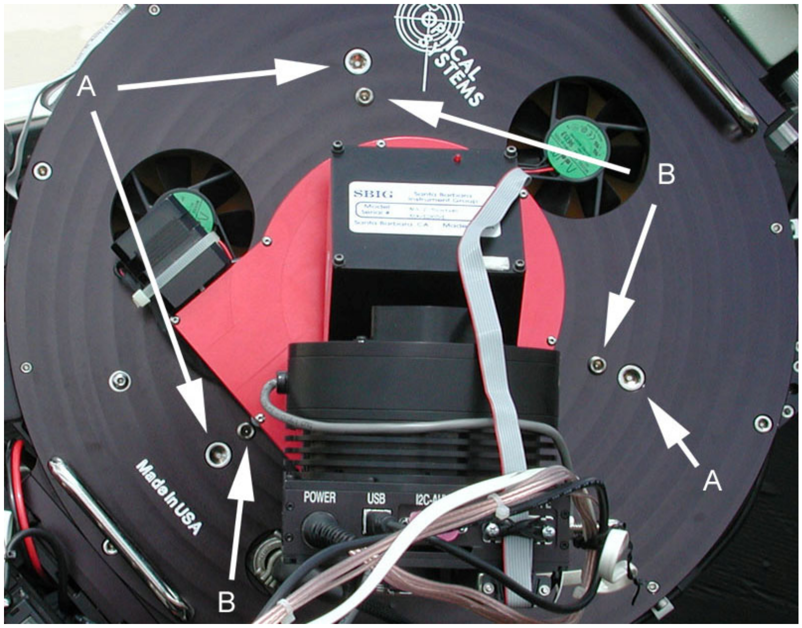

Figure 6: Back view

Now that the secondary mirror optical axis is aligned with the viewing axis, this step adjusts the primary tip/tilt to line up with the secondary. Look at the back plate of the OTA as shown in Figure 6. Again you will note three sets of two screws spaced 120 degrees around the back plate. The outer three, labeled “A” in Figure 6, are “pull adjustments” – they pull the primary mounting plate toward the back plate. The inner three, labeled “B” in Figure 6, are “push adjustments” – they push the primary mounting plate away from the back plate to the degree the pull adjustments allow. The push adjustments are essentially locking screws.

If the telescope has been shipped uncollimated (14.5” and larger), the pull adjusters are fully clockwise. You need to loosen these to get some adjustment range. Unscrew each of the three adjusters equally around 1.5 turns. The push adjusters will now be loose and no longer contacting the mirror mounting plate.

Again look in the Takahashi scope. Moving radially out from the secondary dot, you will see a light area, the image of the end of the Takahashi scope and another much larger dark area, which is comprised of the primary baffle and primary mirror locking collar. Next, a small annulus of light should be visible and finally an outer dark ring, which is the secondary baffle. The object of the primary tip/tilt adjustment is to have this annulus of light as symmetrical (equal width around the circumference) as you can possibly make it.

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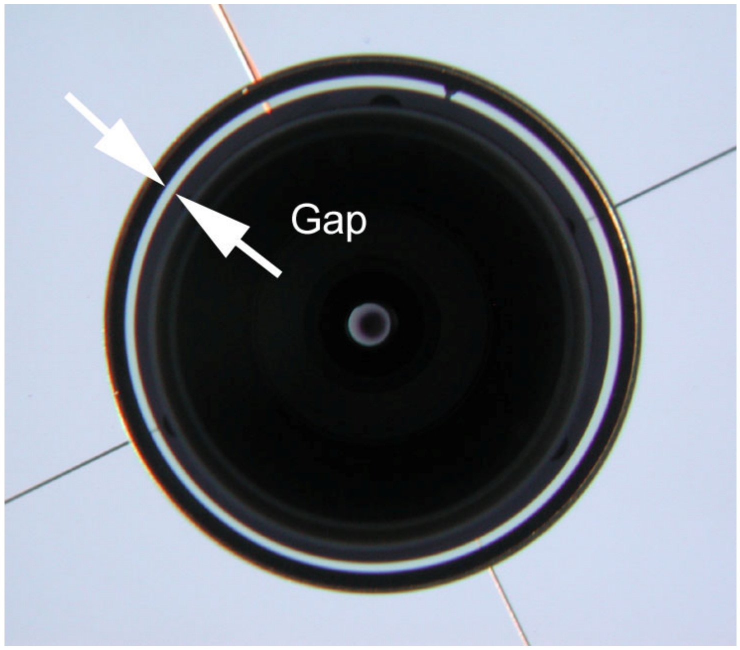

Figure 7

Figure 7 identifies the gap that is to be made symmetrical. (As an aside, note the mark in the gap at 1 o'clock. This is the secondary indexing mark that is applied on the mirror itself. The white secondary index mark shown in Figure 1 refers this mark to the back of the secondary mounting plate for alignment ease.)

This symmetry adjustment is achieved by adjusting the pull screws while looking in the Takahashi scope. Adjust these screws in small increments to get this annulus of light as symmetrical as possible. Once you are satisfied with this adjustment, snug up the push screws. As before, again check the symmetry of the annulus and adjust if necessary by loosening the appropriate push screw and tightening the corresponding pull screw.

Now recheck the secondary dot and Takahashi scope dot for symmetry. If it is no longer symmetrical, repeat the secondary tip/tilt adjustment, followed by the primary tip/tilt adjustment. Repeat as necessary until the symmetry is as good as you can make it.

As you are doing these final steps, you may find it useful to walk away from the OTA once you have it done as well as you can for a few minutes. When you return, you may see some asymmetry that you didn't see before. Adjust as needed and be sure the push screws are all snug before you are done.

When you are satisfied with the symmetrical appearance of the blot, dot and annulus ring, you can proceed to the star test. Do not make any further adjustments to the secondary focuser during the star test. You will rapidly go away from the correct secondary alignment and must return to the daylight collimation to re-establish the correct the secondary alignment.

2. Star Test

A star test consists of looking at a moderately bright star with good seeing conditions after the scope has come to thermal equilibrium. With your telescope mounted and tracking, you are ready to begin final collimation using a star. Locate a bright star near the zenith and center it visually in the eyepiece field of view. Use a moderate to high power. Slightly defocus the star and look for asymmetry in the rings surrounding the star. Slightly adjust the primary tip-tilt adjustments to minimize the asymmetry. Move the star back to the center of the field of view after any adjustment. The adjustments should be very small, 1/6 of a turn or less, if you were successful on the daylight collimation. Don't be surprised if no further adjustment is needed on the star test. If you were very exacting in the daylight test, this could be the case.

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If the seeing is exceptionally good, you may begin to see the Airy disk and the first ring. Critically focus the star and look carefully for the first ring. If it is continuous and unbroken, you are perfectly adjusted; if not, you may make very small adjustments to the primary tip/tilt.

There is an excellent web page on Collimation written by Thierry Legault at http://perso.club-internet.fr/legault/collim.html. This site is highly recommended for the fine points of star testing and some examples of collimated and uncollimated stars, both in focus and out of focus.

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