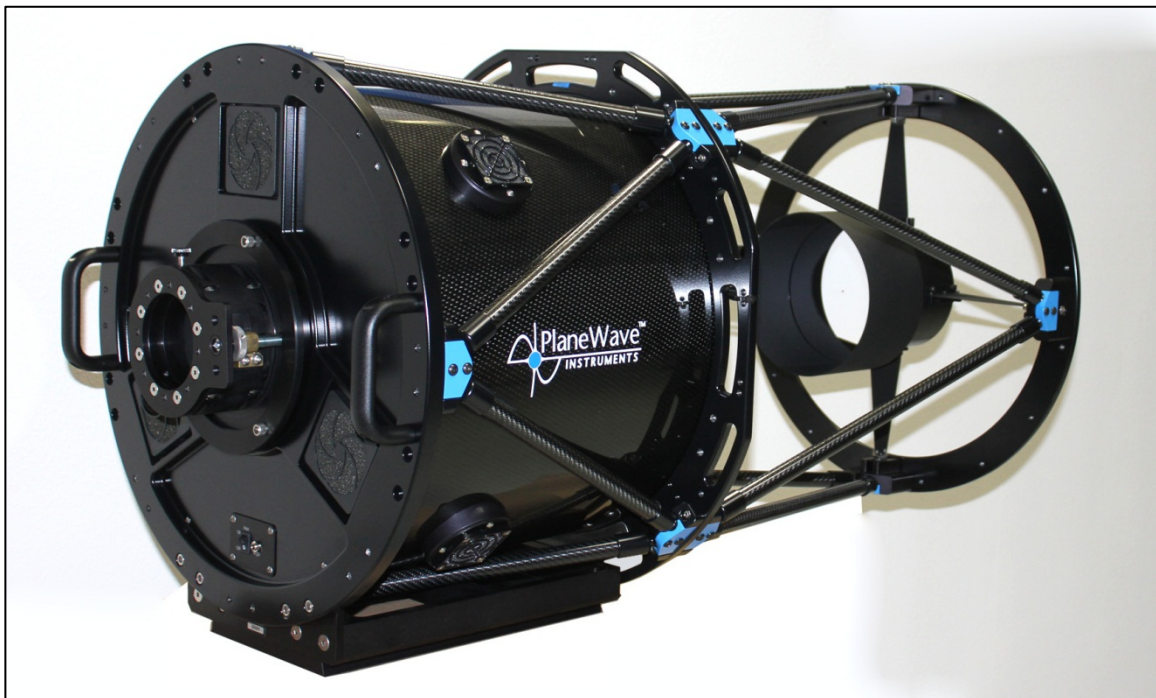




PlaneWave CDK Telescope Instructions

Setting the spacing and collimation for the CDK14/17/20/24



July 10th, 2020

Collimation and Secondary Spacing Procedure

The CDK optical design has four optical elements shown in Figure 1. The primary mirror and the two-element lens group are permanently mounted and aligned at PlaneWave Instruments. The secondary mirror is movable to allow fine collimation and to set the spacing between the primary and secondary. To get the best performance out of the CDK optical system, the optics must be collimated. **Please note that the primary-to-secondary spacing is set at the factory and typically does not need to be adjusted unless it was moved after shipping.**

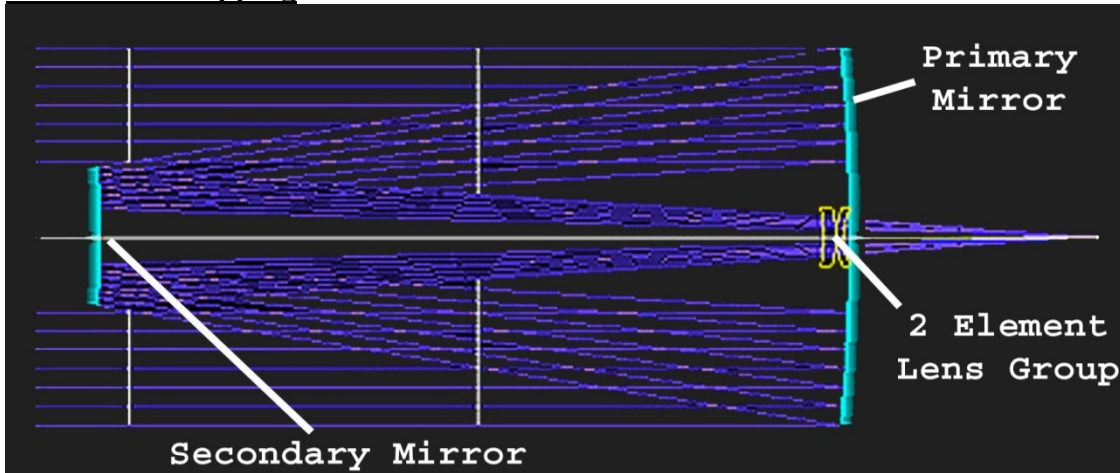


Figure 1: The optical layout of the CDK system. The system contains 4 elements: the primary mirror, the secondary mirror, and a two-element lens group.

Step 1: Collimation / Spacing Adapters for the CDK 14/17/20/24

If your CDK came with the optional Hedrick focuser (200340) attached, You must first remove the attached focuser before attaching the optional Ronchi adapter and spacer.

- a. Use an 3/16" hex wrench and remove the three socket head bolts that holds the focuser retaining ring. Make sure that you are holding the body of the focuser while removing the screws

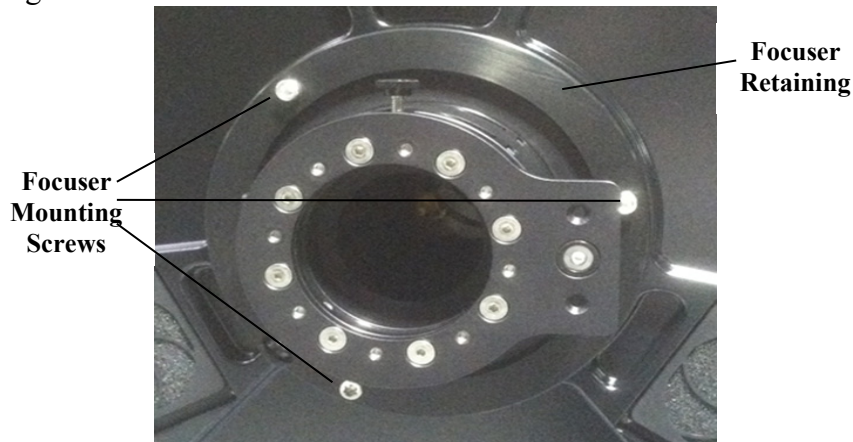


Figure 2 – Focuser and Retaining Ring

- b. Remove focuser from the back plate of the telescope.
- c. Place the optional Ronchi adapter in the back plate of the telescope and replace the focuser retaining ring to hold the adapter in place. See Fig 4

Note: For packaging purposes the optional Ronchi Adapter may come in two pieces; the round mounting plate and the adapter. There should be three 10-32 Flat head screws included to attach the two pieces.

- d. Fully seat the optional Ronchi spacer into the Ronchi adapter and lock it down with the thumb screw.
- e. Place the barrel of a low power eyepiece (for collimation) or the optional Ronchi ocular (for spacing) into the optional Ronchi spacer and lock it down with the thumb screw.

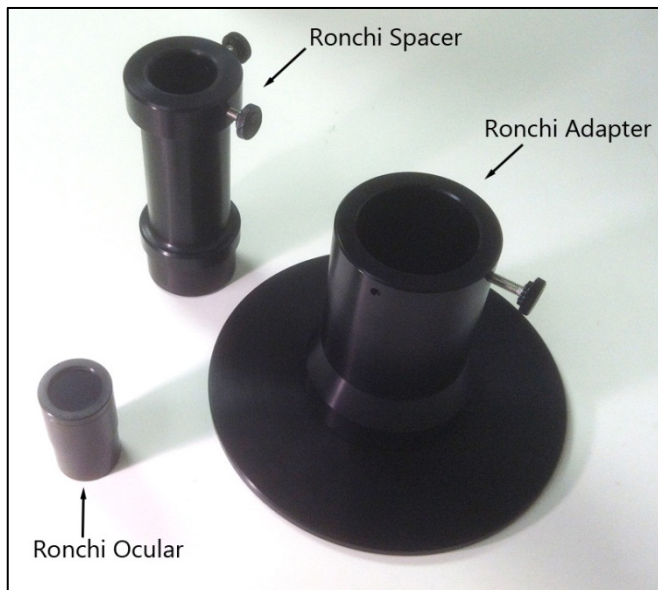


Fig3 – Adapters required for CDK14-24 telescope



Fig 4 – Ronchi Ocular, Spacer and Adapter

Step 2: Rough Collimation:

To collimate your CDK you will need to have a low power, 1.25" eyepiece inserted into the optional Ronchi spacer.

- a. Point the telescope at a bright star.
- b. Defocus the star until it becomes a donut-like ring. If the donut hole appears well centered in the donut, proceed to Step 5.
- c. If the donut hole is not centered, adjust the collimating screws on the back of the secondary mirror so that the defocused star moves in the direction of the fat side of the donut, as shown in Figure 5. Re-center the star and repeat this process until the donut hole looks centered as shown in Figure 6. See below for details on how to adjust the collimating screws.

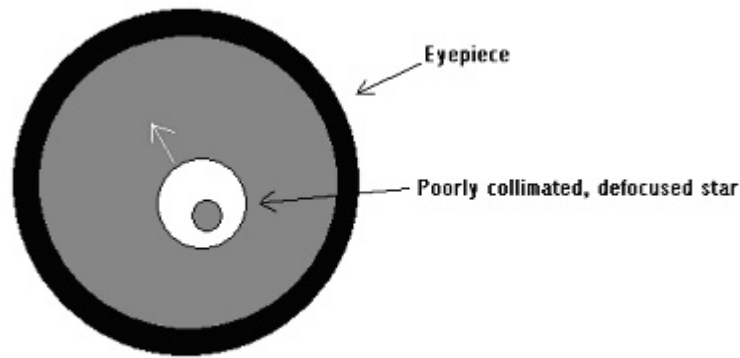


Figure 5: An example of what you would see through a low-power eyepiece for an out-of-focus, out-of-collimation telescope. To collimate this telescope you would adjust the secondary collimating screws so that the out-of-focus star moves in the direction of the arrow.

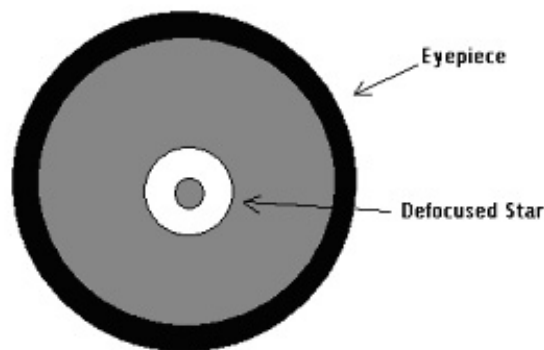
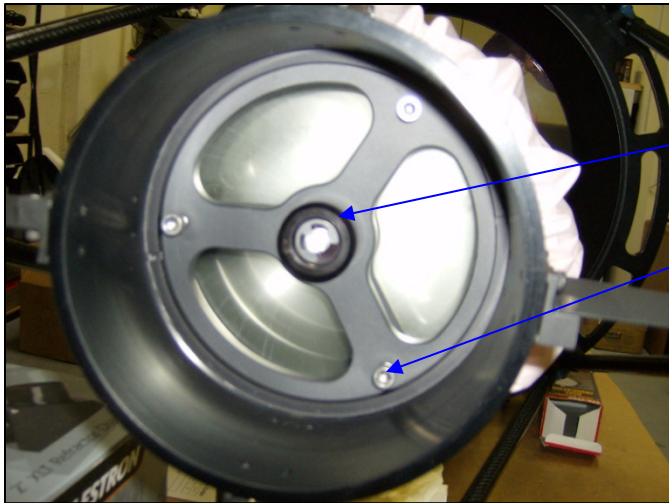


Figure 6: An example of an approximately collimated defocused star.

The CDK uses three $\frac{1}{4}$ -20 socket head cap screws for collimation, as shown in Figure 7. These screws require a $\frac{3}{16}$ Allen wrench. It may be necessary to slightly loose the two opposing screws in order to tighten the third screw. Remember to always finish tightening with the secondary preloaded securely against all three screws.

Collimating is usually a two-person job: one person looks through the eyepiece while one person adjusts the collimating screws. Attempting to do this alone can be quite difficult and frustrating. If necessary, you might try using a webcam or video-rate planetary camera with a 1-1/4" nosepiece in place of an eyepiece. With this setup, you can watch the video stream from the camera while you make adjustments.

Note that the central spacing knob is set at the factory and should not need to be adjusted unless significant adjustments are made for collimation or if movement has occurred in shipping.



Central Spacing Knob

Collimating screw

Figure 7: The CDK secondary housing. There are three collimating screws and a central knob. The secondary on the CDK is spring loaded, pulling the secondary into the three collimating screws

Step 3: Setting the Primary-to-Secondary Spacing:

The primary-to-secondary spacing is set at the factory and should not require adjustment. If significant adjustments requiring multiple turns of the collimating screws are needed for rough alignment or movement has occurred in shipping the optional Ronchi adapter and spacer may be used as necessary.

For your CDK optical system to perform as well as it should, the spacing between the primary mirror and secondary mirror should be set to an accuracy of $\pm 1\text{mm}$! Fortunately, you won't have to directly measure this spacing. When the primary-to-secondary spacing is set correctly, the focal plane will land at an exact known distance behind the fully racked in focuser. The Ronchi Adapter and Spacer places the Ronchi grating of the Ronchi Ocular precisely where the focal plane is supposed to be.

About the Ronchi Test

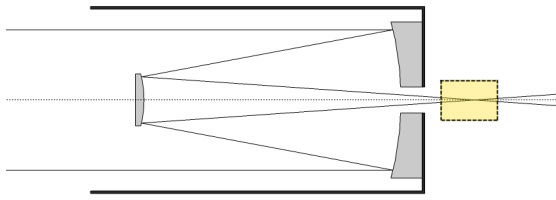


Figure 8 illustrates the basic idea behind using a Ronchi grating to identify the position of the focal plane. The light from a single bright star passes through the optical system and converges to a point on the focal plane. When the Ronchi grating is placed in front of or behind the focal plane, it will block some of the light in this light cone. This will cast a series of shadows that appear as dark, wide lines when the defocused light is viewed through the ocular.

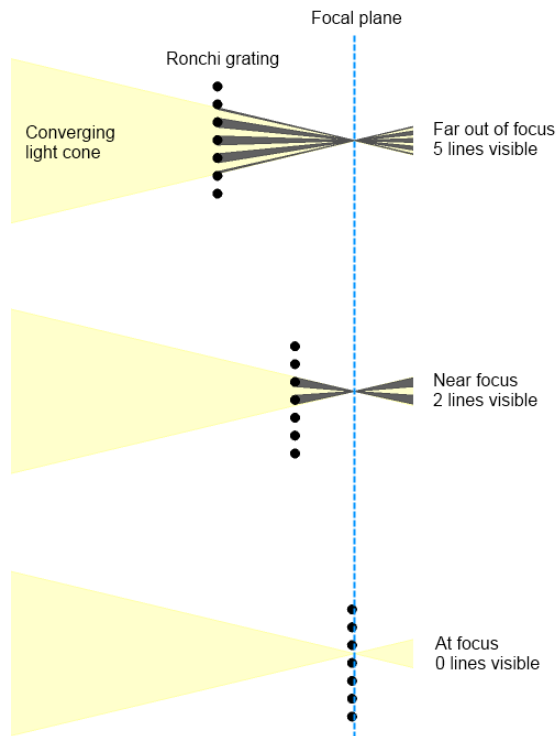


Figure 8: The Ronchi grating casts fewer shadows as it moves closer to the focal plane.

As the grating moves closer to the focal plane, fewer lines are visible, and they become wider. When the focal plane and the Ronchi grating are perfectly aligned, no lines (or perhaps one very wide line) are visible. See Figure 9 for an example.

In order to set the primary-to-secondary distance, you will be moving the secondary mirror. By adjusting secondary mirror distance, you will be moving the focal plane relative to the fixed position of the Ronchi grating. The job here is to move the secondary mirror such that the focal plane coincides with the Ronchi grating on the Ronchi Ocular. When you have done this, you have accurately set the primary-to-secondary spacing.

With reasonable effort, the primary-to-secondary spacing can be set to well within its 1mm tolerance.

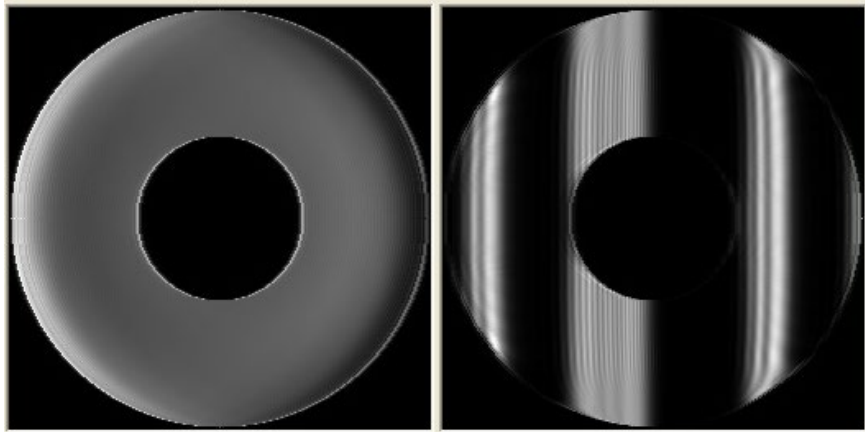


Figure 9: The left image is a simulation of what a focused star looks like through a Ronchi grating. The right image is a simulation of what an out of focus view looks like through a Ronchi grating. The right image shows 2 full lines. The more lines you see, the farther the Ronchi screen is from the focal plane.

Step 4: Setting Up the Test

Starting with a telescope that is fairly well collimated, center a bright star and replace the low power eyepiece with the optional Ronchi ocular. Make sure the ocular is fully seated into the adapter. If the Ronchi is nulled (you can see no lines, or one Ronchi line covers the entire aperture; see Figure 9) This means that your spacing is already set; you may proceed to Step 4. This is not uncommon because the primary-to-secondary spacing is set at PlaneWave and you should not need to adjust it.

If you see two or more lines, you should move the secondary toward or away from the primary.

Determining the Direction to Move the Secondary

To determine which way to move the secondary, gently slide the Ronchi Ocular out of the spacing tube. If the Ronchi reaches null as you do this, the focal plane is too far back and you need to move the secondary mirror **away** from the primary. If the number of lines grows as you slide the Ronchi out of the spacing tube, the focal plane is too far forward and you need to move the secondary **toward** the primary.

Remember that the secondary mirror acts as a magnifier. So a small change in secondary spacing can translate into a much larger change at the focal plane. For example, for every 1mm the secondary spacing is changed on the CDK17, the focal plane moves 4.4mm. You want to keep the error at the focal plane to 5mm or better, which equals just under two lines on the Ronchi. This corresponds to an error in primary-to-secondary spacing of about +/- 1.1mm. See table below for spacing tolerance for all CDK models.

CDK	Focal plane change for every 1mm of secondary spacing change	Allowable primary-to-secondary spacing tolerance to keep focal plane within 5mm of optimal
14	4.9mm	+/- 1.0mm
17	4.4mm	+/- 1.1mm
20	5.1mm	+/- 1.0mm
24	4.1mm	+/- 1.2mm

Figure 9 shows a Ronchi simulation with the Ronchi screen set at the focal plane and also with the focal plane 10mm away from the Ronchi screen. The image on the left is what you will see if the primary-to-secondary spacing is perfect. The image on the right is what you will see if the primary-to-secondary spacing is off by about 2mm. Remember, you want better than 1mm spacing accuracy for the CDK17.

Adjusting the Secondary Spacing

The CDK secondary mirror is spring loaded but you should maintain tension in the collimating screws and the central bolt by making small adjustments. To move the secondary **toward** the primary mirror:

1. Loosen the collimation screws. Loosen them in equal amounts to maintain your collimation.
2. Hold the secondary housing with one hand. This is to keep the housing from rotating. *(The collimation screws sit in shallow recesses and you would like them to go back in the recesses when the procedure is complete).*
3. Rotate the central spacing knob by hand in a **clockwise** direction. **For reference, rotating ¼ turn moves the secondary .4mm, which moves the focal plane 1.76mm in the case of the CDK17.**
4. Tighten the collimation screws in equal amounts until the assembly is tight again.
5. Check the Ronchi grating and repeat this process as necessary until you get a null.

To move the secondary **away** from the primary:

1. Loosen the collimation screws. Loosen them in equal amounts to maintain your collimation.
2. Hold the secondary housing with one hand. This is to keep the housing from rotating. *(The collimation screws sit in shallow recesses and you would like them to go back in the recesses when the procedure is complete).*
3. Rotate the central spacing knob by hand in a **counter-clockwise** direction. **For reference, rotating ¼ turn moves the secondary .4mm, which moves the focal plane 1.76mm in the case of the CDK17.**
4. Tighten the three collimation screws in equal amounts until the assembly is tight again.
5. Check the Ronchi ocular and repeat this process as necessary until you get a null.

Re-checking Collimation

After you are satisfied that the secondary spacing is correct, replace the optional Ronchi ocular with the low power eyepiece and repeat step 1 to verify that the collimation is still close. If re-collimation adjustments are necessary, make them and proceed to Step 5.

Step 5: Fine Collimation:

Use a high-power eyepiece (5mm or less) and follow the same procedure described in Step 1 (adjust the secondary so that the donut hole is in the center of the donut). You may want to switch to a low-power eyepiece while adjusting, and back to high power to check the collimation. Remember to carefully re-center the star between making adjustments to the secondary mirror alignment.

As long as only small adjustments were made in Step 3, the spacing as set at the factory should be within tolerance. If it is not, follow Step 2 and Step 3.

Back Focus

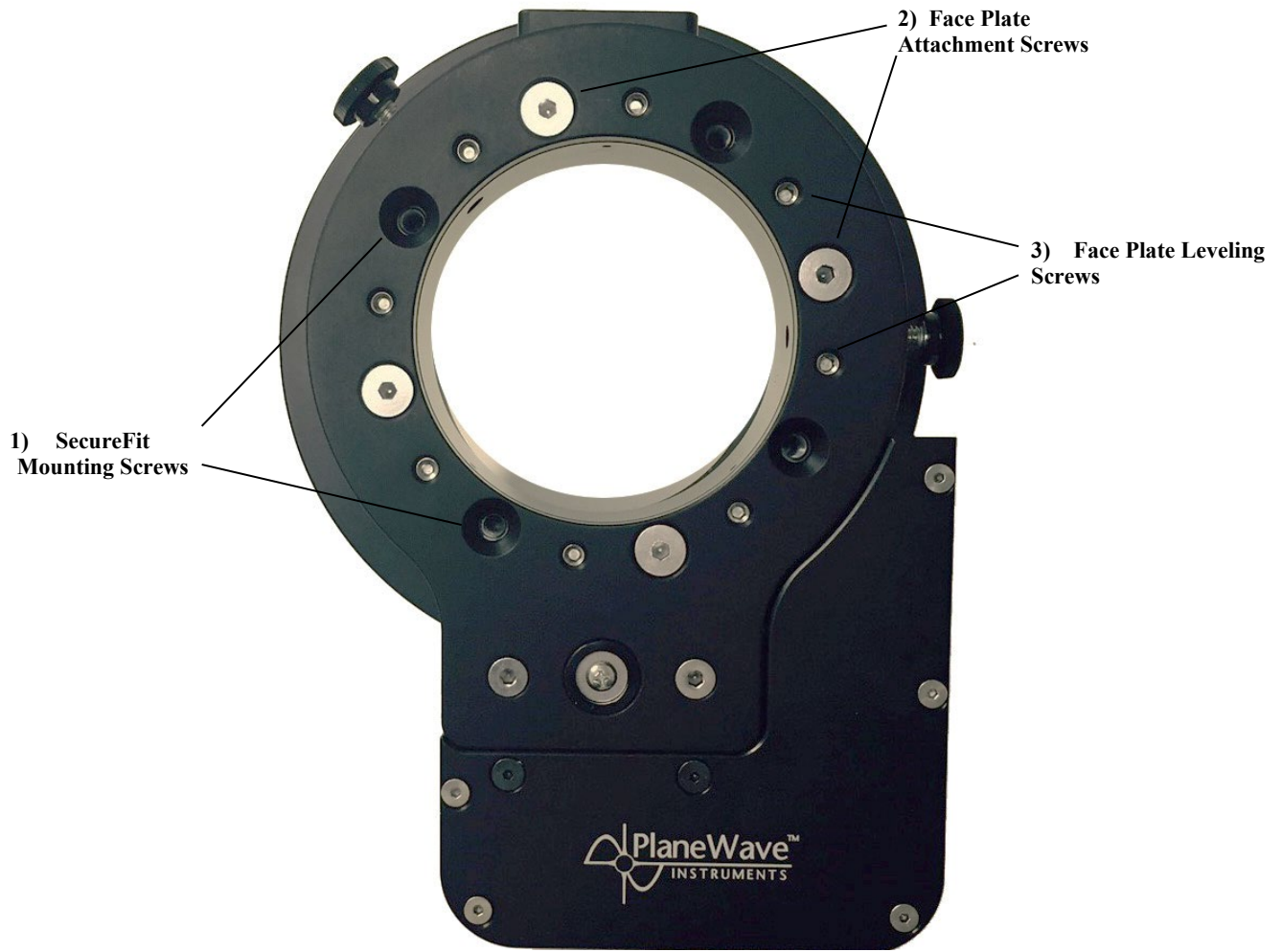
The CDK design does not have any moving optical components, so the focal point is fixed. This means that the focal plane of the telescope is a set distance behind the backplate of the telescope. The back focus for the various telescope models is shown in Table 1 below.

	Backfocus from mounting surface of telescope backplate	Back focus from fully racked in focuser
CDK14	11.09"	8.09"
CDK17	10.24"	7.24"
CDK20	8.81"	5.81"
CDK24	*14.1"	5.81"

Table 1: Shows the back focus with and without the focuser installed for the various PlaneWave telescope models.

*CDK24 can also use optional spacers to increase back focus to be the same as the CDK17 or CDK14.

Mounting SecureFit Spacers to the Hedrick Motorized Focuser



1. The face plate of the focuser (200340) has four threaded holes that should be used to mount any of Planewave's SecureFit adapter. Use the $\frac{1}{4}$ -20 screws provided with your SecureFit adapter to mount it on the face of the focuser.
2. The remaining four holes has screws that hold the face plate to the body of the focuser and should not be removed.
3. There are also a series of set screws that are used to level the face plate relative to the image plane. These set screws should not be removed or loosened in any way.