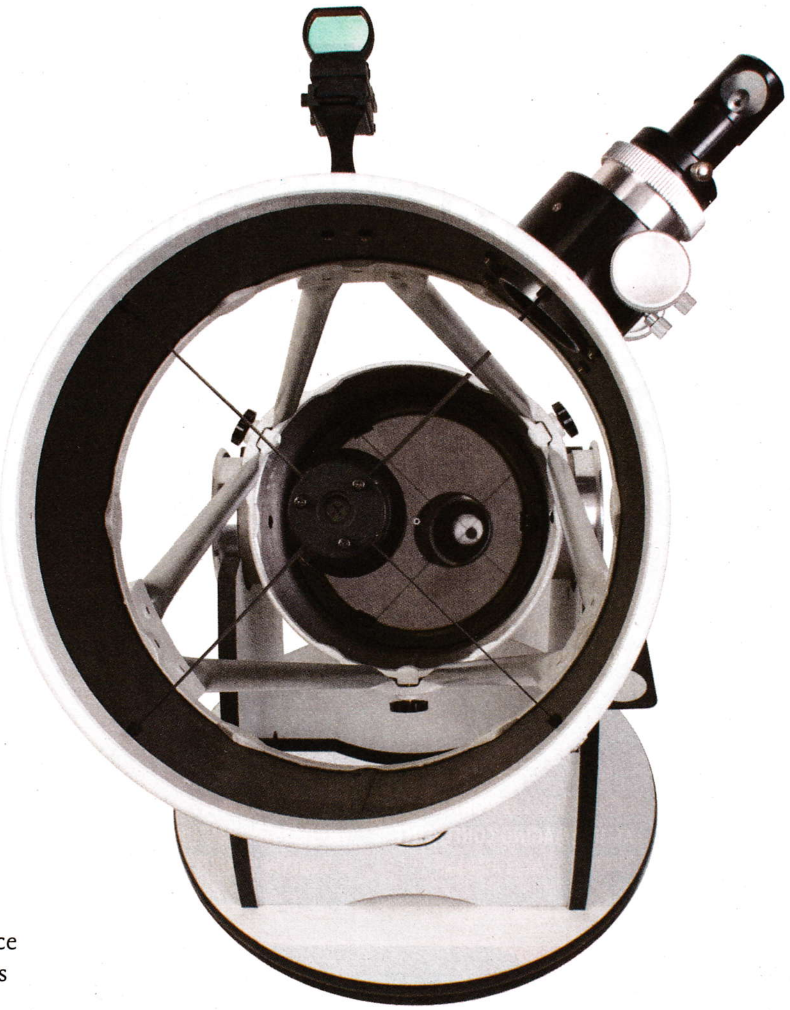
Nurture YOUR NEWT II: Collimation

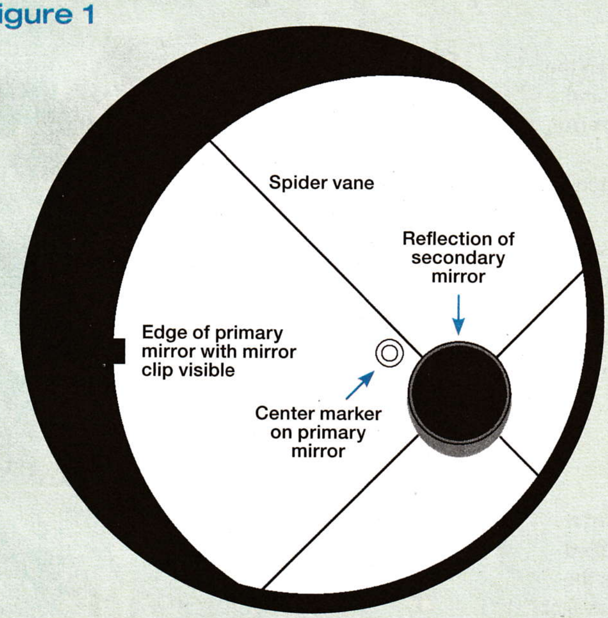
Aligning your reflector's mirrors — critical to getting the best view — is easier than you think.



In our first installment of this series, we talked about keeping your Newtonian telescope clean and how to wash the primary mirror when it gets dirty. Now let's look at how to collimate it.

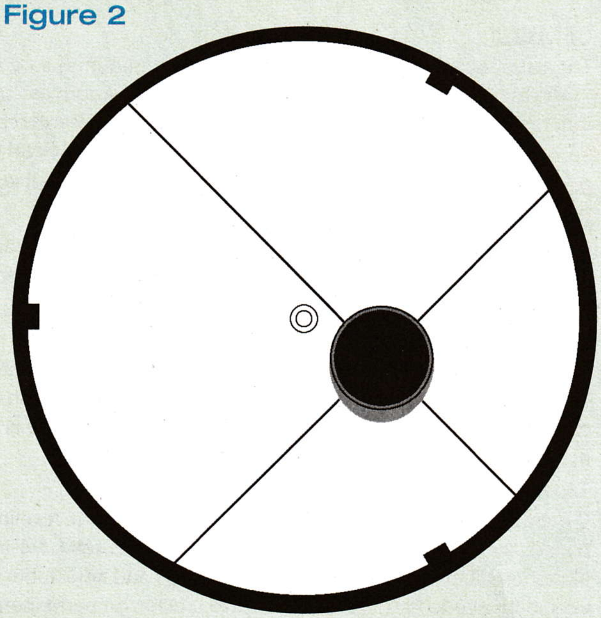
Like mirror washing, collimation is a lot easier than many people think. The Internet is so full of scary advice on collimation that many people think it's as dangerous

Figure 1



▲ **OUT OF WHACK** You'll see something like this when neither the primary nor the secondary mirror is aimed properly. Each illustration depicts the telescope pointing straight up.

Figure 2



▲ **SECONDARY ALIGNED** When the secondary is adjusted properly, the entire primary will be visible within its perimeter. Note that all three mirror clips are equally visible.

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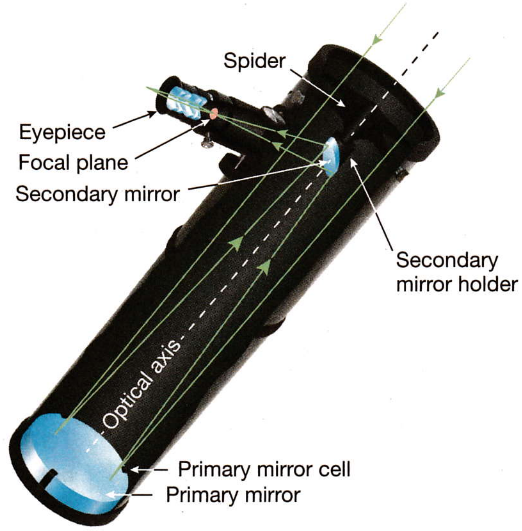
ALIGNMENT ANXIETY One of the most frequently noted disadvantages attributed to the Newtonian reflector is its need for regular collimation of its two mirrors. But this supposed disadvantage can be reduced to a minor task if approached methodically.



as choosing whether to cut the red wire or the green wire when defusing a bomb, but it's really pretty simple. The hardest part is probably learning to say it properly. (It's coll-i-ma-tion, not cul-min-a-tion or coll-im-na-tion.)

Collimation means lining the mirrors up in a straight line. The primary mirror needs to be pointing more or less straight out of the tube, the secondary mirror needs to be more or less centered over the primary, and it needs to bounce incoming light down the center of the focuser's drawtube. I say "more or less" because the primary's aim down the tube isn't all that critical, and the secondary is seldom truly centered. In fact, it's usually deliberately off-center. We'll get to the "why" of that in a minute.

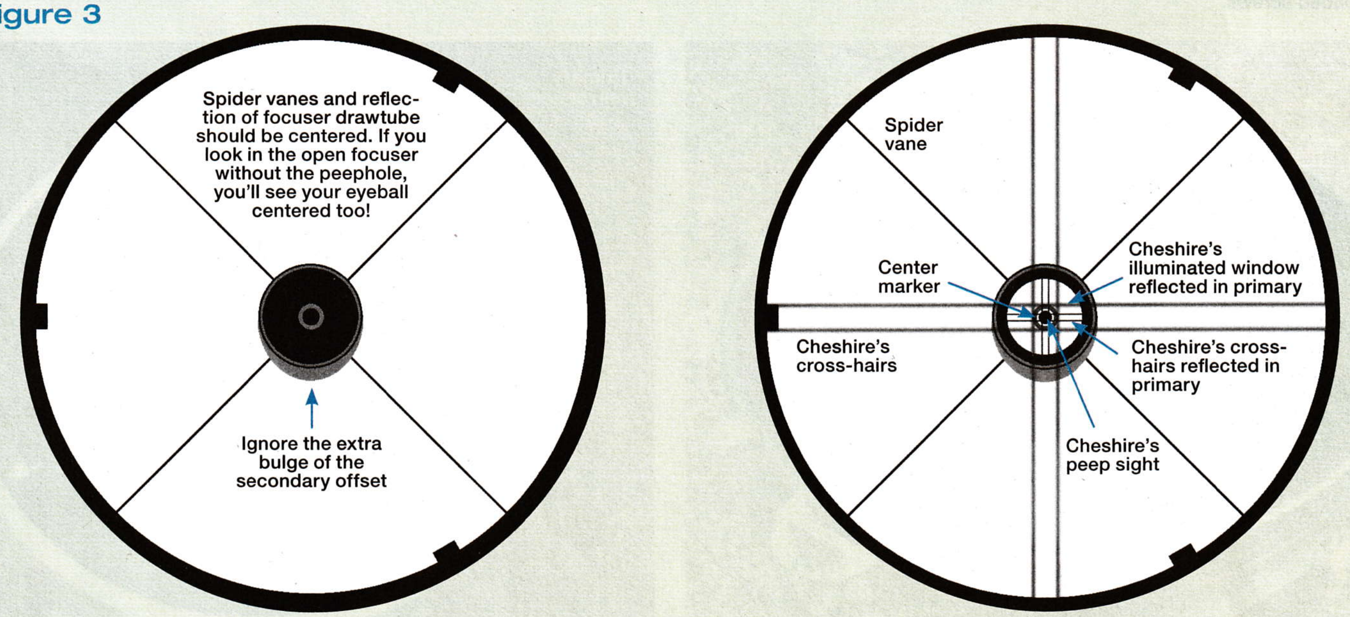
Begin With the Secondary

You start your adjustments at the top of the scope. If you've already looked up collimation instructions online, you may have found some whose first step is "Square the focuser." Scratch that. Unless somebody drop-kicked your scope across the observing field, your focuser is fine. So start by making a peephole about 1/8″ in diameter that goes in the focuser like an eyepiece. A 35-mm film container with the bottom cut off and a hole drilled in the cap works great for this if you can find one. In a pinch, you can tape some paper over the focuser and poke a hole in it. The purpose of the peephole is to force your eye to stay centered over the drawtube.

Check first to see if the secondary is too high or too low in the optical tube. It probably won't be, but it might be if someone fiddled with it. You can use the far end of the focuser's drawtube as a reference. The shiny part of the secondary should look centered within that circle. (You might have to put a piece of white paper behind the secondary and wave a flashlight around to see where the edges of the secondary are.) A *Cheshire eyepiece* (a collimation tool consisting of a sight tube containing a beveled reflective surface and crosshairs) makes this a little easier by constricting the diameter of the reference circle, but you can do fine with just your centered eyeball. This adjustment doesn't need to be exact; just get it close, both vertically and horizontally.

The next step is to align the secondary mirror so you

Figure 3



▲ **IN PERFECT TUNE** *Left:* When both mirrors are aligned properly, everything will be centered except possibly the outline of the secondary mirror. *Right:* A Cheshire eyepiece provides crosshairs and a bright inner reference circle. This view also shows the optics in collimation.

can see the entire primary mirror when you look through the peephole. If you see something like **figure 1**, where the primary mirror looks off-center (don't worry about the reflection of the secondary and spider for now), then you need to adjust the secondary until the primary appears centered. Use the adjustment screws on the secondary mount for motion toward or away from the focuser, and rotate the secondary rather than tilt it for left-right motion. (Tilting it sideways will de-center it in the focuser's drawtube.)

Once the primary looks centered within the secondary, look at the reflection of your secondary, spider, and focuser drawtube. If it looks like **figure 2**, you need to adjust your primary mirror until the reflection looks like **figure 3**. Centering can be estimated much more easily if you mark the exact center of your primary mirror (if it's not already marked by the manufacturer, as some are). A small dot with a Sharpie works well, though a self-adhesive hole reinforcing ring used in 3-ring binders is even better for this. In either case, the center marker will not affect your image when observing at all, since it's in the shadow of the secondary mirror.

Don't be confused by the perimeter of the secondary mirror. That will probably not look centered when everything else is, because your secondary has likely been offset slightly away and downward from the focuser to account for the extra distance to the lower half of the secondary from the focuser. (Objects farther away from your eye look smaller, so most ATMs and some commercial manufacturers put more mirror on the far side to compensate.) So just pay attention to the reflection of the spider and focuser drawtube.

Once you've aligned the primary, that's it. You're collimated. Lock down the primary with the lock screws if you have them. Just snug them up. Don't tighten hard.

The faster your scope, the more critical the collimation. The "sweet spot" in the field of view gets smaller and smaller with faster primaries.

Technological Assist

But what about lasers?! Doesn't everybody need a laser? Or at least a combination Cheshire/sight tube?

Nope. Because you can star test. Once you've gotten the collimation as close as possible by sighting through the empty focuser, take the telescope outside at night and aim it at Polaris or, in the Southern Hemisphere, Sigma Octans (because those stars won't move much while you're performing the test). Put your highest-power eyepiece in the focuser and center your test star in the field of view. Now rack the image out of focus just a little and look at the fuzzy donut of light. If it's round with the shadow of the secondary mirror in the middle, you're done. If it's oval or comet-shaped and the secondary shadow is squished toward one side, move the telescope so the image shifts around in the field of view and note in which direction the image looks

▼ **SECONDARY ADJUSTMENTS** *Left:* The secondary mirror can be tilted and rotated. Some adjusters have three screws, some four (not counting the center bolt). *Right:* The primary mirror adjustment will generally have three screws that pull and three that push. Some may just have three spring-loaded screws.

most round. Leave it there and adjust the primary mirror to bring it back to the center. (It's often best to have a helper with this process, since it's difficult to watch the image and move the mirror at the same time.) You may have to repeat this moving-away-and-recentering several times, but you should eventually be able to get a symmetrical out-of-focus image in the center of the field of view.

To confirm your collimation, bring the image to focus. It should shrink to a sharp spot, with faint hints of diffraction rings around it if the seeing is exceptionally good. (Note that you'll never get a pinpoint star image. The nature of light limits the smallest image your telescope can create, so you'll get what's called an Airy disk — a tiny disk surrounded with faint diffraction rings — and you'll only see that under excellent atmospheric conditions.)

When you get a symmetrical out-of-focus donut and sharp focus, you're done! Enjoy the view through your perfectly aligned telescope.

Oh, okay. You've got a laser and you want to use it (because lasers are cool!). Here's how:

You'll first need a center marker on your primary, and the very center of that marker needs to be open. (That's why a self-adhesive hole reinforcing ring is useful: It has a hole in the middle.)

After you've determined that the secondary is centered in the view of the focuser (because the laser can't tell you that), stick the laser in the focuser and aim its side window toward the primary mirror so you can see the window while turning the collimation screws. Then snug up the clamp just as you would on an eyepiece.

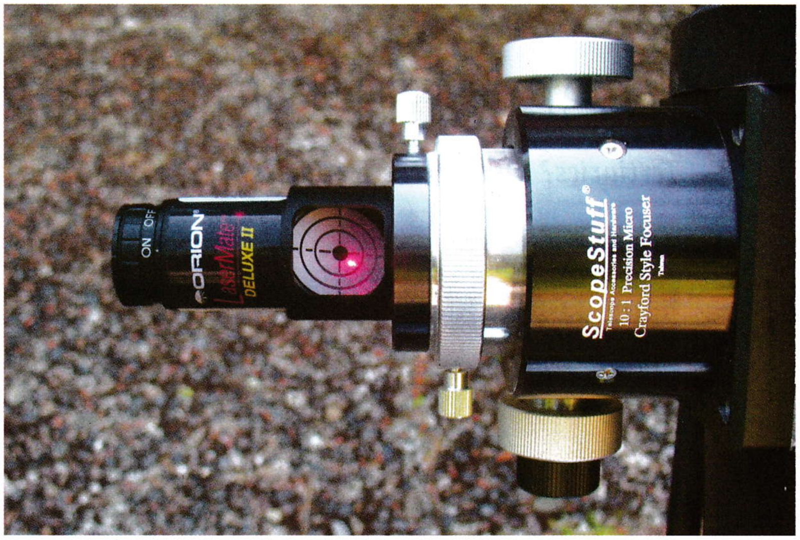
Turn on the laser and look down the front of the telescope tube. Does the laser beam hit the center of the primary's center marker? If not, adjust the secondary until it does. Remember to use the tilt screws only for motion toward and away from the focuser, and rotate the mirror for sideways motion.

Once the laser beam is centered on the primary, look at the side window of the laser collimator. The return beam should go right back into the hole it came out of. If you don't see the bright spot, the beam is either already dead-on or it's so far off that it's not hitting the window. You can wiggle the collimator to see which it is.

If the beam is misaligned, turn the primary mirror's collimation screws to bring it to center, then lock down the primary with the lock screws (if you have them). Then star test as above.

So what about the Cheshires mentioned earlier? They merely help you do the same as the peephole method, by giving you better reference points in the form of crosshairs and an illuminated circle. I highly recommend using a Cheshire (I prefer them to lasers), but it's an enhancement on the peephole method, not a replacement for it.

A couple of notes: The faster your scope, the more critical the collimation. The "sweet spot" in the field of view where you get a perfect out-of-focus donut gets smaller and smaller with faster primaries. If you want good views through the eyepiece, keep fast scopes well collimated. Slower than f/5 or so, you can get away with a lot of slop (comparatively speaking), because the sweet spot will probably not be far from the center of the field even if your collimation is off a little.



▲ **FOLLOW THE DOT** A laser collimator is quick and convenient, but it's not a complete replacement for the eyeball method.

Several months ago a reader asked if the secondary offset I mention above would affect the star test. Wouldn't the secondary shadow at the middle of the light donut be offset a little? And would that offset be enough to throw off the alignment if you centered the secondary shadow? Yes and no. Technically the offset should be visible. Just hold your hand in front of the scope while performing a star test, and you can see that any obstruction will appear offset if that obstruction itself is offset. But a typical secondary offset is on the order of an eighth to a quarter of an inch. On an 8-inch primary, that means it's about 1.5% to 3% of the light donut's diameter. You're unlikely to see that small a deviation by eye.

Like collimation itself, this effect will become more pronounced with faster scopes because the secondary offset is often greater. It's probably never going to be enough to matter, but if so, the solution is simple: Cut out a circle of paper a little larger than your secondary and set that on top of the spider, making sure it's perfectly centered. As long as the paper's diameter is large enough to completely mask the secondary, the light donut will be symmetrical when the scope is collimated.

If you followed the procedure in the previous article in this series, you now have a clean and collimated telescope. There are as many nuances to the procedures I set forth as there are amateur astronomers. There are other methods I haven't even mentioned. (Google "collodion mirror cleaning" for a thrill.) But the methods I've described will serve you well and will keep your Newtonian telescope functioning like new.

■ Contributing Editor **JERRY OLTION** star tests every time he goes out, but that's because he's, shall we say, fussy.