

Collimation with a Barlowed Laser

Improve your Newtonian's performance with this quick and simple procedure. | **By Nils Olof Carlin**

IN RECENT YEARS LASER COLLIMATORS have gone from being an exotic novelty item to just another piece of equipment in a Newtonian telescope owner's eyepiece case. In large part they have supplanted the reliable old Cheshire eyepiece as the collimation tool of choice. At first glance, the laser seems to offer a high-tech approach to the problem of accurately aligning a reflector's optics, with the added benefit of being convenient to use at night. However, achieving collimation with a standard laser collimator is not as simple or as certain as it might at first seem. Indeed, even when closely following the manufacturer's instructions, owners of fast Newtonians (those with f/r ratios around 5 or less) may not achieve satisfactory collimation, let alone collimation as good as is possible with a Cheshire. But can the laser collimator be made more accurate? Absolutely! And the procedure for doing so is disarmingly simple.

Collimation Basics

Aligning the optics of a Newtonian reflector essentially consists of three steps, only the last of which needs to be repeated routinely on most telescopes. This procedure was described in detail in my previous article on collimation (*S&T*: June 2002, page 111) and is summarized here. Performed with care, these steps will result in a perfectly collimated scope.

Regardless of collimation method, you need to mark the center of the primary mirror. With standard laser collimators, a doughnut-shaped paper reinforcing ring works well, but a simple spot with no hole is fine for the procedure described here.

The first step is to make sure the secondary mirror is aligned with the focuser. You do this by centering the secondary mirror in a sight tube inserted into the focuser. Begin by rotating the secondary holder until you see the primary's center



A standard laser collimator can yield unsatisfactory optical alignment. However, using such a device with an ordinary Barlow lens allows collimation on a par with the precision obtained with a good Cheshire eyepiece. All photographs are by Craig Michael Utter, *Sky & Telescope*.

spot roughly centered in the secondary. Next, move the secondary back and forth along the telescope tube and “sideways” (perpendicular to the back-and-forth motion) by adjusting the spider — leave the small adjustment screws on the back of the holder alone for now. This step also automatically ensures that the sec-

ondary is properly offset.

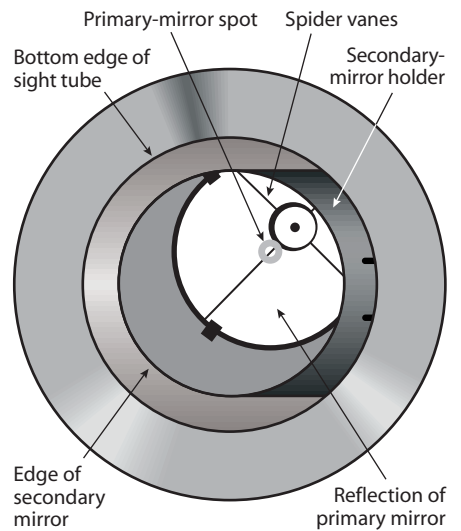
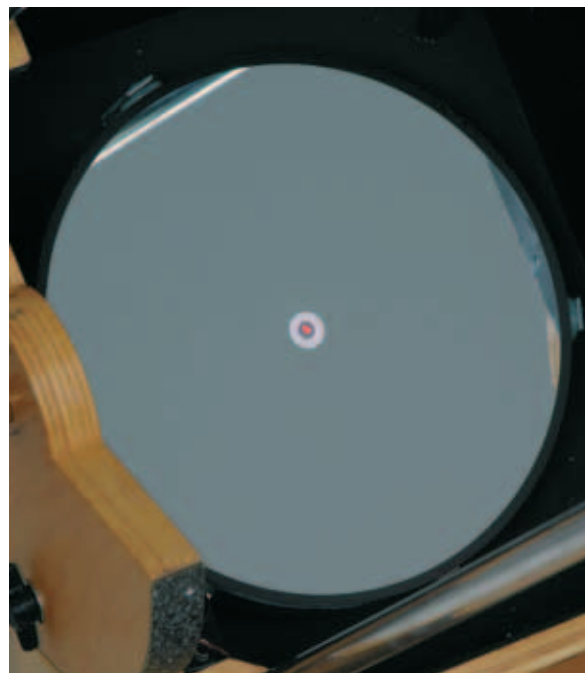
In step 2, you adjust the tilt of the secondary mirror to ensure that the center of the focuser and the center of the primary mirror are coincident. A standard laser collimator is ideal for this job — you insert it into the focuser, turn it on, then adjust the small screws on the secondary-

mirror holder to make the laser beam hit the center of the primary mirror.

By far, the most important part of the collimation procedure is step 3 — the only step you will normally have to repeat on a regular basis. Here, you adjust the collimation screws of the primary mirror's cell to center the mirror's optical axis in the focuser. In my previous article I recommend doing this with a Cheshire eyepiece. Once this step is accomplished, the mirror's "sweet spot" will be centered in the eyepiece. Why is this important? Because the sweet spot is very small, especially in fast telescopes. For example, an $f/4.5$ primary has a diffraction-limited field only 2 millimeters (0.08 inch) across! Outside of this small area, the telescope's mirror performance begins to worsen, which is why it is critical that this good zone be centered in the eyepiece — the *raison d'être* of collimation.

A Laser Miscollimator

When you perform step 3 with a laser, you adjust the collimation screws of the primary-mirror cell to make the beam retrace its path back to its source, where you can see it hit some kind of target or faceplate. If the return beam is 1 mm off the center of the face plate, it means the optical axis is off center by half this, or 0.5 mm — indicating close to perfect collimation. So what is the problem? This accuracy is possible only if in step 2 the beam strikes the center of the primary mirror *exactly*. Suppose it misses by a mere 2 mm — a level of accuracy that



The first step in collimation has been accomplished — the secondary mirror is mechanically centered with respect to the focuser drawtube. When performing this step, ignore all reflections.

can be difficult to judge from the front of the telescope tube. This trivial error in step 2 is much too small in itself to affect the performance of the telescope, but it may have grave consequences in step 3.

To illustrate how, let's suppose that somehow the primary mirror is already perfectly aligned with the eyepiece — the scope is effectively perfectly collimated. But because the laser missed the center of the primary by 2 mm in step 2, the beam will return parallel to the mirror's optical axis and hit the laser faceplate 2 mm off center.

If you then adjust the primary to center the returning beam, without realizing it you will have shifted the sweet spot 1 mm away from the center of the eyepiece's field of view — an amount great enough to affect the quality of high-magnification views. This is the real Achilles' heel of the laser collimator and likely ex-

Step 2 in collimation is to adjust the secondary mirror's tilt until the laser beam strikes the center of the primary mirror. This ensures that the reflection of the focuser's axis is aimed at the center of the primary.

plains why many users don't get the results they expect from their telescopes.

But even if you were able to achieve step 2 with perfect accuracy, you might still have problems. It is a fact of life that the mechanical parts of a telescope are given to flexure and a certain amount of slop. Try this: The next time you use your laser collimator for step 2, rack your focuser in and out. Does the beam still hit the center of the primary mirror? Try tightening the setscrew that holds the collimator in the focuser. Does the beam wander around? If yours is like most focusers, it probably will. By contrast, the Cheshire eyepiece is quite insensitive to minor errors in step 2 — it shows only the collimation error of the primary. For this reason it typically produces more accurate results.

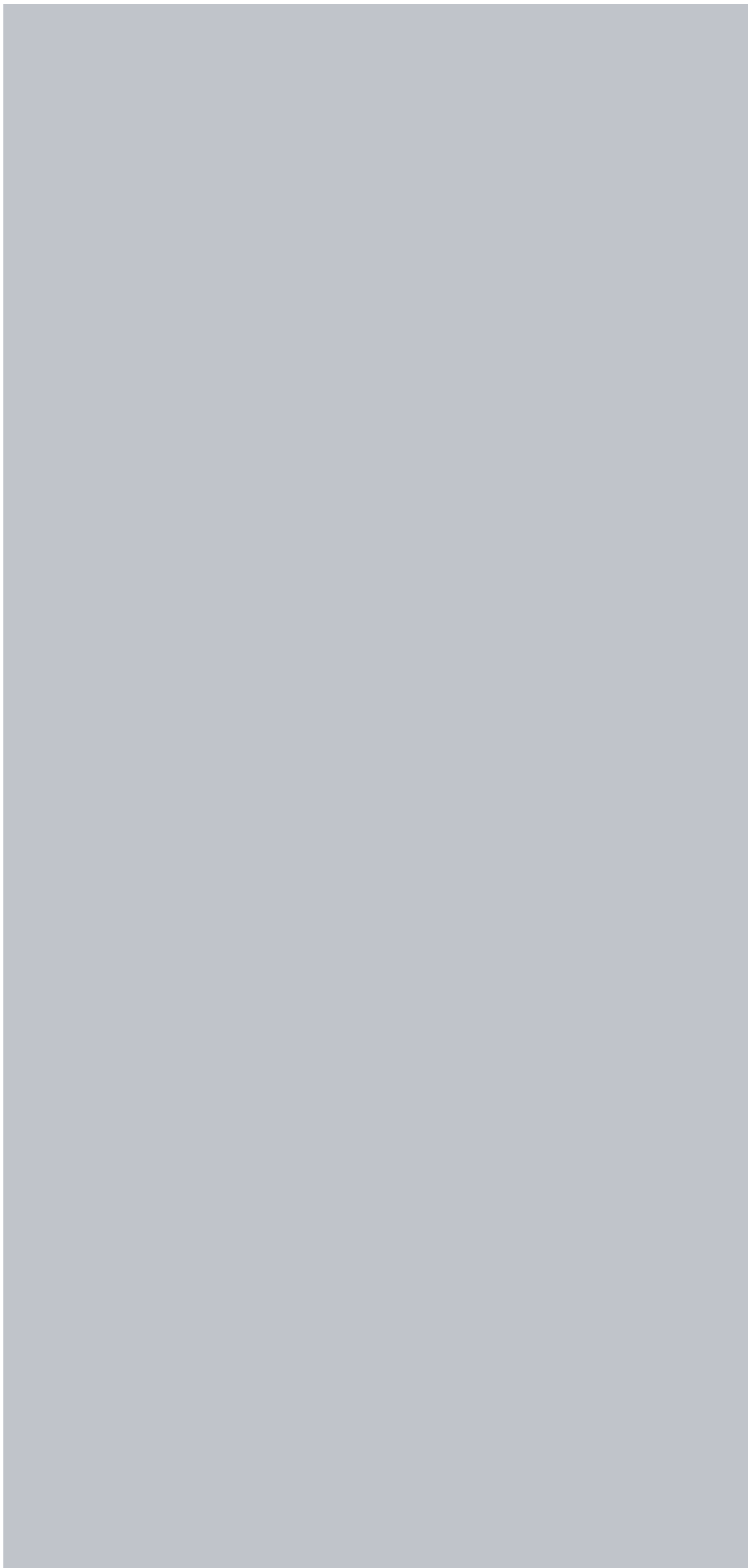
Making It Really Work

What if you could combine the ease and convenience of a laser collimator with the accuracy of the Cheshire? It can be done, and it's not even very difficult.

To get around the problems described above, what is needed is a point source emitting a diverging beam of light instead of the usual narrow laser beam. When this diverging beam reflects off the primary mirror, a sharply defined silhouette of the center spot returns to the light source. If this spot shadow is centered on the light source, the primary mirror is collimated as accurately as it can be.

So how can one generate the necessary diverging beam? A negative lens of suitable focal length will make a laser beam diverge as if it were coming from a virtual point source located at the focal point of the lens. The ideal lens would, of course, be mounted in a housing that can be placed in the focuser and can also hold the laser collimator. Chances are that you already have exactly such a thing in your equipment box: a Barlow lens!

The only modification required is to add a faceplate, to show the returning beam of light and the shadow of the primary mirror's center spot. As illustrated in the photograph on the following page, this can be made from a disk of white cardboard or plastic with a central hole large enough to pass the outgoing laser beam. First, use a compass to trace a circle of the same size as the inside diameter of the Barlow's barrel. Next, carefully cut the circle with an X-acto knife or scissors. Last, punch a hole in the center of this disk, using an ordinary paper hole



punch, taking care to center the punch on the tiny hole from the compass tip. This perforated disk can be mounted either directly to the Barlow or, as shown here, to a thread-in color filter (choose a filter that matches the color of your laser beam or remove the glass). The latter option allows the collimation screen to be easily removed. Alternatively, if you have an old, poor-quality Barlow sitting in a junk drawer, you can permanently mount the screen and have a dedicated collimation tool.

Using the Barlowed Laser

Collimating with the Barlowed laser differs from the normal collimation procedure described above only in step 3. Step 1 is performed with a sight tube as usual, and step 2 is done with the laser used in the normal manner. This done, you insert the Barlow lens in the focuser and the laser collimator in the Barlow, turn the laser on again, and view the shadow of the center spot on the Barlow faceplate. (In the unlikely event that the primary is so badly out of collimation that you can't see the shadow at all, you will first have to roughly collimate using the laser or a Cheshire.) Use the collimation screws for the primary mirror to center the shadow, as shown below. Once this is completed, your scope is collimated.

It might not be obvious that the Barlowed laser actually works in an *entirely* different way than the standard laser. It's easy to demonstrate the difference. Try the tests mentioned before — rock the drawtube gently, move it in and out, or tighten the screw that locks the Barlowed laser in the drawtube. Where the beam from the normal laser collimator danced around, the silhouette of the mirror spot is rock steady. This means that the Barlowed laser, like the Cheshire eyepiece,



Above, left: The Barlowed laser consists of three main pieces: an ordinary laser collimator, a Barlow lens, and a screen consisting of a cardboard disk mounted in a color planet filter (red, in this case).



Above, right: By inserting the laser collimator into the Barlow lens equipped with its perforated screen, you have a tool capable of providing collimation as accurate as that provided by a Cheshire eyepiece but with the convenience of a laser.


shows only the collimation of the primary mirror without errors induced by focuser slop.

Practical Considerations

The lasers in collimators do not have uniform light distribution, so the spot may not be round or evenly illuminated. This does not matter as long as you can see the mirror-spot silhouette clearly outlined. Since the light source is close to focus, this silhouette will be the same size as the spot itself.

Also, the diverging beam of light should be wide enough to cover the primary's center spot, though it need not be exactly centered on it. What is important is that both the laser and the Barlow lens should be well centered on the focuser axis. Most likely they are, but it is easy to check. Rotate the Barlowed laser combi-

nation in the focuser — the spot of light on the primary may move a little, but the returned shadow should remain essentially stationary.

For this method to work, you must be able to see the bottom faceplate of the Barlow in the focuser. If the Barlow is too short or the focuser is too tall, use a small hand-held mirror to view it. For scopes with long tubes, a carefully positioned mirror can also help when you are collimating the primary mirror — you can view the effects of your adjustments in real time. 

A self-taught collimation expert and amateur telescope maker, NILS OLOF CARLIN resides in Ystad, Sweden. His Web site features extensive information on telescope use, telescope making, and collimation (including FAQs): <http://w1.411.telia.com/~u41105032/>.



This sequence of photographs shows that with the Barlowed laser combination, final collimation is as simple as adjusting the primary mirror's tilt until the silhouette of the primary's center dot (a binder reinforcement ring, in this case) is centered on the exit hole of the Barlow's screen.