Howie's Laser Collimator Instructions:

WARNING: AVOID DIRECT OR MIRROR REFLECTED EYE EXPOSURE TO LASER BEAM

The laser collimator is a tool that enables precise adjustment of the alignment of telescope optics to obtain the best possible image contrast and resolution. Inside the collimator is a solid-state laser diode that emits an intense light beam exactly along the central axis of the cylindrical collimator body. The beam acts as a reference line from which alignments are made. The holographic collimator has, in addition, a transparent diffractive optic placed just ahead of the laser. It diffracts some of the laser's light to project a diverging pattern symmetrically around the beam. This projected pattern is used to align optical elements by making the perimeter of the element symmetrical within the pattern. The standard pattern is a 10 x 10-line square grid. It allows direct centering by symmetry of f/35 to f/2.7 optical systems. Because there are some collimating situations in which the projected pattern is not necessary or desirable, the diffractive element (also known as a hologram) unscrews from the laser aperture, converting the collimator to single-beam mode. Be careful when replacing the diffractor to start the screw threads correctly aligned. For maximum alignment accuracy, the diffractors are individually fit to their collimators, so if you know someone else who has one of my collimators, be careful not to accidentally or purposely switch diffractors.

A removable plastic aperture stop with a 1 mm hole that produces a smaller, circular beam is supplied with all except 532 nm collimators. On the holographic collimators, the diffractor must be removed to fit the stop. The stop is useful in situations where the full beam is too bright, or where greater collimating precision can be gained with a tiny spot.

The laser used is class IIIa; maximum output 5 milliwatts. Direct or mirror reflected eye exposure should be avoided, but there is no problem in viewing the beam's impact on a surface that produces a diffuse reflection, or on a mirror or lens surface if the reflected or transmitted beam is not directed towards your eye. A badly miscollimated Newtonian or Cassegrain can bounce the beam out the front of the scope, so when collimating, always check first by pointing the scope at a wall or screen to see if the beam is getting out. With a refractor the beam will always exit the front of the telescope, so run a strip of masking tape across the dew cap opening to act as a safety beam stop.

To begin telescope collimation the collimator is placed in the eyepiece holder and the reference beam is projected along the eyepiece axis. It's important to tighten the eyepiece clamp so that the collimator aligns with the eyepiece holder. In an oversize holder, tightening the clamp may push the collimator sideways slightly, but this is not significant if the holder is truly cylindrical; what's important is that the collimator be exactly parallel to the holder axis. Because laser collimation proceeds from the eyepiece axis, true alignment of and with that axis is quite important. If the eyepiece holder is misaligned, the other optical elements will wind up off-center in the tube. If the eyepiece holder alignment is not stable and shifts when focused, the holder should be put in its "average" position, and care taken to not move it during collimation.

If you find that the holder alignment is off or unstable, some telescope mechanic work may be in order. If adjustment screws are provided they should be used. If not, the holder or focuser might be adjusted by using shims or washers, filing or machining, or replacement.

Newtonian collimation -

Focuser alignment: For rough collimation, you need not align the focuser unless it is grossly misaligned, but for best performance, the focuser should be aligned with respect to the main tube. The focuser and main tube axes must *intersect*, and in most cases, should intersect at a right angle.

First, remove the secondary mirror and its holder. The spider can stay in place. You will also need a carpenter's or framer's square or something that can serve that function. At least one leg of the square should be as long as the tube's diameter. Also, a combination square with a sliding blade will come in handy but will be used only as a depth gauge. Something homemade can easily serve this function, too.

Check that the front opening is square with the tube by holding one leg of the square against the outside of the tube and the other leg across the tube opening. If you have a truss tube, you will need to establish a line parallel to the tube axis as a reference for the square. This can be done with a long straight stick, dowel, truss pole or extruded aluminum angle, etc. Tape the stick to structural features near the top and bottom of the tube at equal distances from the tube center-line; then use the square.

Place the collimator in the focuser and turn it on. Measure from the front edge of the tube back to the laser beam, measuring along the inside surface of the tube or upper cage. You can use the combination square to make this measurement by placing its head against the front edge of the tube and sliding the adjustable blade back along the inside surface of the tube until its end just grazes the laser beam. Measure this distance at two places; near and opposite the focuser. It should be the same on both sides. If not, adjust the focuser so that the distance between the front edge and the beam are the same on both sides. This sets the focuser square with the tube axis.

Next, cut a strip of cardboard, wood or other stiff material to just span the tube's inside diameter. Mark the center of the strip and place it spanning the tube's inside diameter at right angles to the focuser axis. Adjust the focuser axis, tipping it side to side, until the laser beam is centered on the mark. This sets the focuser axis intersecting the main tube axis. Reinstall the secondary.

Secondary collimation: In f/6 or longer telescopes the secondary should be centered within the tube’s diameter. In f/6 or faster scopes the secondary can be slightly de-centered away from the focuser. This is necessary if the secondary has been sized to just intercept all of the converging rays from the primary because the ellipse formed by the intersection of the plane of the secondary with the converging cone of light from the primary has its center offset from the optical axis. If you know the amount of offset for your telescope you may adjust the secondary support or spider to move the secondary away from the focuser by the required amount. This can be set by measuring with a ruler or caliper from the spider hub or the mirror edges to the tube wall.

Next, move the secondary parallel to the tube axis so that it will reflect the converging image beam coincident with the focuser axis. You can look through the empty eyepiece holder and adjust the secondary so that its edges appear concentric with the top and bottom edges of the eyepiece tube. This will automatically produce the proper offset of the secondary towards the primary.

The holographic collimator can be used to position the secondary by centering the projected pattern on the surface of the secondary or centering the shadow of the secondary within the grid pattern projected on the tube wall behind it. This also produces the proper offset towards the primary. The shadow method will only work well if the secondary has a "skeleton" type holder.

Rotate the secondary on the main tube axis so that the mirror faces the focuser squarely. You can make this adjustment with the single beam collimator by temporarily tipping the secondary either towards or away from the focuser, using its adjustment screws. Then, rotate the secondary so that the reflected laser spot reaches a point in line with both the secondary and focuser. Lock the secondary rotation adjustment at this point.

Next, the secondary is adjusted so that the laser beam strikes the center of the primary mirror. First, check that the primary is centered within the tube so that the optical axis will coincide with the tube axis. Check it all around with a ruler and adjust the cell centering if necessary. Then adjust the secondary so that the laser beam from the collimator hits the primary at its center. With a single beam collimator, it's impossible to judge this accurately by eye, so you need to have a dot or ring placed on the center of the primary to allow accurate secondary adjustment. Don’t worry about putting a dot on your primary: the center is not in use because it’s in the shadow of the secondary. A ring is preferable because a completely opaque dot will not allow the laser beam to reflect from the primary; however, a dot made with a permanent marker will transmit enough light to allow collimation. I supply self-adhesive collimation rings with the collimator. Here are two methods for dot placement:

1. Tape two dark threads to the edges of the mirror at right angles to each other stretched across diameters of the mirror. Looking from directly above, place the self-adhesive ring on the mirror with fine tweezers. You can run a support across and above the mirror to rest your hand on.
2. Cut a circle the exact size of the mirror from thin, soft, uncoated paper and fold it in quarters. Cut the folded tip to produce a hole just slightly larger then the dot or ring, when unfolded. Place the paper on the mirror and tape it at the edges or slide three blocks against the mirror to keep the paper centered. Place the dot down with tweezers, as above.

Of course, you must work cleanly and carefully and not allow anything but the paper to touch the mirror surface.

The holographic collimator allows secondary adjustment without a center dot on the primary by making the pattern symmetrical at the edge of the primary.

Primary collimation: The beam reflected from the primary goes back up the tube to the secondary mirror and is reflected by the secondary to the face of the laser collimator where the beam impact glows brightly. This can be seen from the front of the telescope, looking down the tube, by double reflection in the primary and secondary. You may need someone to help you by turning the primary adjustment screws while you look down the tube. Adjust the primary to move the reflected spot towards the center of the collimator face until it disappears in the brightness of the laser aperture. With the holographic collimator, you can center the innermost pattern square around the laser aperture. The primary adjustment can also be done by making the up and down going laser beam's impact points on the secondary coincide. With an open tube, this can facilitate solo collimation.

There is an additional method of primary collimation with the holographic collimator if the focuser has been aligned and the primary centered in the tube. It uses the fact that the telescope will work in reverse to turn the diverging rays from the diffractor into parallel rays and project the pattern on a surface in front of the telescope. You can adjust the primary by centering the projected pattern around the shadow of the secondary. You can also place translucent paper over the tube opening and observe the pattern there. If the secondary is offset away from the focuser, take this into account when observing its shadow within the pattern.

Refractor Collimation: For refractor alignment, the collimator is placed in the eyepiece holder (straight through; no diagonal prism or mirror), and the drawtube axis is checked for alignment by seeing if the beam passes through the center of the objective. With a single beam collimator, you can cut a paper circle the same size as the front cell opening and punch a hole in its center to check beam centering on the objective. With a holographic collimator, the paper is not needed, as the centering of the pattern on the objective can be seen directly. If the beam does not pass through the center of the objective, the tailpiece or drawtube should be realigned. Usually, there are no adjustments provided for this, so telescope mechanic work will be necessary.

The next step is to adjust the angular alignment of the objective so that the beam, reflected from the center of the rear element, is returned to the collimator face and centered on the laser aperture. Enough light is reflected, even from an anti-reflection coated lens, to perform this adjustment. If you are using a holographic collimator the diffractive element should be removed to brighten the central beam and to keep the diffracted pattern out of your eyes. If objective alignment is off and its cell is not adjustable, telescope mechanic work will be needed.

Cassegrain Collimation: The general procedure for laser collimating a Cassegrain is to first check and adjust as necessary the back-axis alignment with the main tube axis and then put the secondary, primary, and corrector plate (if present) successively into alignment with that axis. A single beam collimator allows back axis and secondary alignment, but a holographic collimator is necessary for primary and corrector alignment.

First check by measurement with a ruler or caliper that both the tailpiece or threaded flange on the back of the telescope, and the secondary mirror are centered within the tube, and adjust the centering if necessary. Then place the collimator in the telescope back (no diagonal mirror or prism) and check that the laser beam strikes the center of the secondary mirror. Adjust the back-axis alignment as necessary. With a single beam collimator and a telescope that has a corrector plate, you will have to adjust beam centering on the secondary by eye. With a holographic collimator, you can see if the pattern is centered on the secondary. It is sometimes difficult to see the beam or pattern impact on very clean optical surfaces because the impact is only seen by light scattered from tiny particles of dirt and dust or optical roughness. In most situations, visibility isn't a problem, but in extremely clean sealed systems it may be. Visibility can be improved by lowering ambient illumination.

Schmidt-Cassegrain Collimation: A major problem with commercial SCTs is that the primary, corrector plate, secondary centering and back axis have no adjustments. Only the angular alignment of the secondary is adjustable. Unless all these adjustments are correctly and permanently set at the factory, best theoretical performance cannot be achieved through secondary adjustment alone. If all the non-user adjustable alignments are correct, the secondary can be easily collimated by folding the laser beam back on itself, squaring the secondary with the optical axis.

Because of possible misalignments in the non-adjustable elements, the best setting of the secondary may actually be tipped. This is because tipping the secondary can partially (but never perfectly) compensate some of the image aberration induced by other misalignments. The best way to find the optimal setting of the secondary is with a star test. The secondary is adjusted to produce the most compact image of a star in the center of the field at high power. The resulting secondary adjustment can be precisely measured, recorded and reproduced at any time, using just the single beam laser collimator. The star test should be done without a diagonal unless the diagonal is known to be accurately collimated itself. As soon as the secondary adjustment is judged to be as good as is possible, the eyepiece is removed and the single beam (or holographic collimator in single beam mode) inserted in the back. The laser beam reflects from the secondary and bounces back to impact on the face of the collimator. The exact location of the beam impact is a measurement of the secondary setting. The beam impact can be seen from the front of the telescope, looking through the corrector plate, by double reflection in the primary and secondary. Take careful note of the beam impact position so that you can return the secondary to it any time that it becomes necessary. The small aperture stop increases precision in locating the spot. You can place a mark on the face of the collimator at the exact location, but the collimator must be inserted into the scope in the same rotational orientation each time.

When turning the laser collimator off, be sure to rotate the battery cap counterclockwise at least one turn past laser off to prevent inadvertent activation.

The collimator is warranted against defects in material and workmanship for one year from date of purchase. This warranty does not cover failure or damage cause by misuse, abuse, improper power supply, excessive shock or attempts to adjust or modify collimator.