APPENDIX
B

Cleaning and Collimating Your Telescope

There is very little to wear out on a telescope, and it should literally last a lifetime, but not without some basic maintenance. The constant jostling and exposure to the elements is bound to take its toll, requiring that you clean and collimate the optics from time to time.

For a telescope to deliver the best image possible, precise collimation of the optics is essential. This means all the mirrors and lenses should be centered and angled properly so that light rays hitting the main mirror or lens on-axis form an image in the exact center of the eyepiece. If the optics are not collimated, stars in the center of the field will look like distorted comets flared to one side, rather than symmetrical pinpoints. In severe cases, nothing will come to a sharp focus.

To keep optics clean, follow a few precautions: When bringing a telescope in from the cold, always cap the main optics and pack the telescope and eyepieces in their cases first. Then carry the protected optics inside, and allow them to warm up gradually. This will prevent condensation from forming on them. Once the equipment has warmed close to room temperature, it can be uncovered. Do this even if dew or frost has formed on the optics outside.

A little moisture on the optics now and then will do no harm, but if it happens regularly, corrector plates and lenses can collect a filmy residue, sometimes on both the outside and inside surfaces, forcing more frequent cleaning, which is not good. If the telescope is being used night after night in cold weather, store it in a cold but dry place, such as an unheated garage with a dry concrete floor. This will avoid condensation, and shorten cool-down time.

A word of caution: Clean optics only when absolutely necessary. Vigorous cleaning can do far more harm than some dust and dew spots.

Happiness is a clean and collimated telescope. One reason why owners report their Schmidt-Cassegrains perform poorly is that even a slight miscollimation of an SCT's optics can degrade sharpness.

Cleaning Optics

The chief ingredient of care is the prevention of dust in the first place, so keep the optics covered when not in use. When dust does accumulate on the surface, you can defer a major cleaning job by whisking it off promptly while it is still dust, before a night of heavy dew transforms it into mud.

The best plan is to mix your own cleaning fluid: use distilled water and isopropyl (rubbing) alcohol of the cheapest and least aromatic variety in a ratio of 50-50. Then add a few drops of dishwashing liquid (not dishwasher), just enough to undo the surface tension that causes beading of the water-alcohol mixture on polished glass. The resultant brew is a potent cleaning agent that is safe for virtually any antireflection coating and dries clean with a minimum of polishing.

CLEANING EYEPIECES AND LENSES

Of all optical components, eyepieces require the most cleaning. The eye lenses pick up grease and oil from eyelashes and from misplaced fingers fumbling in the dark. In refractors and catadioptrics, the front lens or corrector plate can gather dust. If dew is allowed to form on these surfaces often, a filmy residue can accumulate.

1. First, blow loose dust and dirt off the exterior lens surfaces with a bulb-blower brush or a can of compressed air. (Be careful with the canned air: if you tilt the can, some of the propellant may spew out spotting the optics with chemical gunk.)

2. Next, use a soft camel-hair brush and very light strokes to remove loose specks. Any that remain could scratch the surface when you perform the following step.

3. For eyepieces, moisten a cotton swab (a Q-Tip) with a few drops of the cleaning fluid mentioned above. For a larger lens, moisten a cotton ball.

4. Gently wipe the lens. Do not press hard. If the stain is stubborn, use new swabs or cotton balls. Sometimes, gently breathing on the lens can help remove stains.

5. Use a dry swab or cotton ball for a final cleaning of moist areas, plus some more air puffs to blow off the bits of tissue that inevitably remain. A few smears might remain, but a final polish with a light condensation from your own breath will restore the pristine appearance.

With Schmidt-Cassegrains, the front corrector plate, complete with the secondary mirror attached, can be removed from the front of the tube. But use extreme care; corrector plates are very thin. Getting at the inside surface of the corrector may be required if the interior of the telescope has become contaminated with dust or moisture. *Important*: The corrector plate/secondary mirror assembly must be put back in the exactly same orientation as you found it.

Lens Cleaning Tips

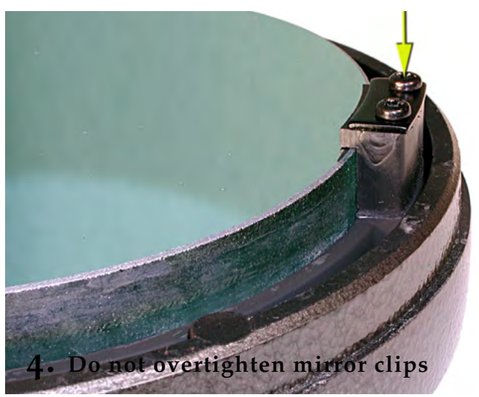
If cleaning is needed —

- Do not use cleaning solutions or cloths sold for eyeglasses. These can leave filmy chemical smears.
- Camera lens cleaners work fine for the small surface area of eyepieces but can smear larger areas of telescope optics. Instead, use the homebrew formula described in the text.
- Do not apply fluid directly onto a lens; it can seep into lens cells and into the interior of eyepiece barrels. As below, clean eyepieces with a moistened cotton swab.
- Never take an eyepiece apart, to remove eyepiece lenses from their mountings. You may never get them back correctly.
- In some refractors, it is possible to remove the front lens assembly (shown at bottom right). This may be necessary to get at the rear lens surface where stains can appear. But never take doublet or triplet refractor lenses apart or remove the lenses from their cell. Replace the cell in the same orientation on the tube as you found it.

1. Remove mirror carefully

2. Wash gently with cotton balls

3. Rinse with distilled water, let drip dry



4. Do not overtighten mirror clips

CLEANING MIRRORS

For most of the lifetime of a Newtonian, the primary and secondary mirrors should require only the occasional blast of canned air and a few strokes of a camel-hair brush. Aluminized surfaces can scratch easily, and a mirror full of microscopic scratches is far worse than a mirror with a few isolated specks of dust on it. Wash a mirror only if it develops a thick film of dust or grime. Follow these steps:

1. Remove the cell from the end of the tube, a task that might require some prying. Then loosen the three clips to remove the mirror from its cell. In some cases, dobs of glue also hold the mirror in place.

2. Once the mirror is free from the cell and safely on a table, use a blower and brush to remove as much dust as possible.

3. Now, place the mirror on edge in a sink on top of a folded towel to prevent it from slipping around.

4. Run cold water over the front of the mirror to wash off more dirt. Do not worry; this will not remove the reflective aluminum coating.

5. Then fill the sink with warm water and a few drips of a gentle liquid soap.

6. Lay the mirror flat in the sink submerged under about half an inch of water. Use sterile cotton balls to swab the mirror gently. Always brush in straight lines across the surface. Never rub or use circular motions. Repeat with fresh cotton balls, moving perpendicular to the first swipes.

7. Drain the sink, then rinse the mirror with cool water.

8. Perform a final rinse with bottled distilled water. Tap water can leave stains.

9. Let the mirror dry by standing it on edge. The mirror should not have to be subjected to this treatment for many years.

Washing a Mirror

STEP 1: Removing this mirror from its cell required pulling it free from dobs of silicone glue.

STEP 2: Place the mirror on a towel in a sink. Clean using the weight of the wet cotton ball as the sole source of pressure. Remove rings from your fingers so the mirror does not get scratched.

STEP 3: Rinse a mirror with distilled water. Dry it by standing the mirror on edge so water drops run off without staining.

STEP 4: When replacing a mirror tighten the clips so they just touch the mirror. Overtightening will pinch the mirror, introducing astigmatism. Recollimation will now be necessary.

Collimating the Optics

The test for poor collimation is simple: slowly rack a bright star out of focus. If the resulting expanding round disk is not symmetrical, there is a problem. On reflectors, the test is especially easy because the central dark shadow cast by the secondary mirror should be dead center in the out-of-focus blur circle.

Commercially made refractors or Maksutovs are collimated at the factory and generally offer no user-adjustable settings. In the event that their optics do require collimation, it usually means a trip back to the manufacturer.

However, if you have a Newtonian or a Schmidt-Cassegrain, collimation is something you should be aware of. Telescopes can arrive out of collimation from the factory. Or the accumulation of small shocks from road trips and from nightly temperature changes over time can eventually degrade the alignment of mirrors.

COLLIMATING SCHMIDT-CASSEGRAINS

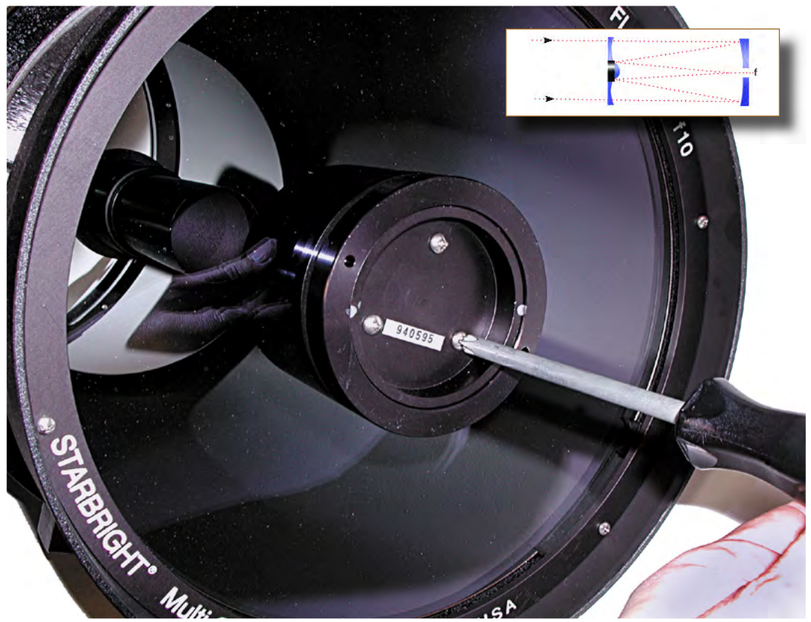
These are the simplest telescopes to collimate. The adjustments are done strictly with the three small screws on the secondary mirror cell. (On some models, the screws are hidden behind a protective plastic cover that must be pried off or turned to reveal the collimation screws.) The idea is to use these screws to adjust the tilt of the secondary mirror so that it projects the light beam straight down the center of the telescope. On most Schmidt-Cassegrains, the secondary mirror magnifies the focal length by a factor of five; its collimation is therefore extremely critical. Even a slight maladjustment can degrade performance. Always approach collimation with a light hand—a mere fraction of a turn may be all that is required.

COLLIMATION PROCEDURE

1. On a night with steady star images, set up the telescope, and let it cool to outside air temperature. This may take an hour but is important as the effects of thermal plumes can mimic poor collimation.

OK, Bad, and Awful
From top to bottom, these simulations depict a star at high power as seen in a Schmidt-Cassegrain with:
• 1/4-wave of coma from slight miscollimation,
• 1/2-wave of coma from poor collimation,
• and 1-wave of coma from severe miscollimation. The bottom two scopes would produce blurry images.

Collimating Cassegrains
When collimating SCTs, take two precautions:
• Some cells (not this one) have a central screw. Don't loosen this—it holds the secondary mirror in place.
• Do not overtighten the three screws. If they warp the secondary, you'll see astigmatic star images.



2. Aim the telescope at a second-magnitude star high above the horizon. Polaris makes a good choice as it won't move much during the process. Use a medium-power eyepiece, but if possible do not use a star diagonal, because it can introduce collimation problems of its own.

3. Place the star dead center, then rack it out of focus until it is a sizable blob. If the telescope is out of collimation, the secondary mirror shadow will appear off-center.

4. Now use the slow motions to move the telescope so that the star image is displaced from the center of the field. Move the telescope in the direction that makes the central shadow appear better-centered.

5. Now turn the collimation screw that makes the out-of-focus star image move back toward the center of the field. This takes trial and error. Remember to make very small adjustments.

6. If the image is still asymmetrical, then repeat Steps 4 and 5. Turning one screw may not be sufficient. A combination of two may be required. If one screw gets too tight, loosen the other two to perform the same move. At the end of the whole procedure, all three screws should be finger-tight.

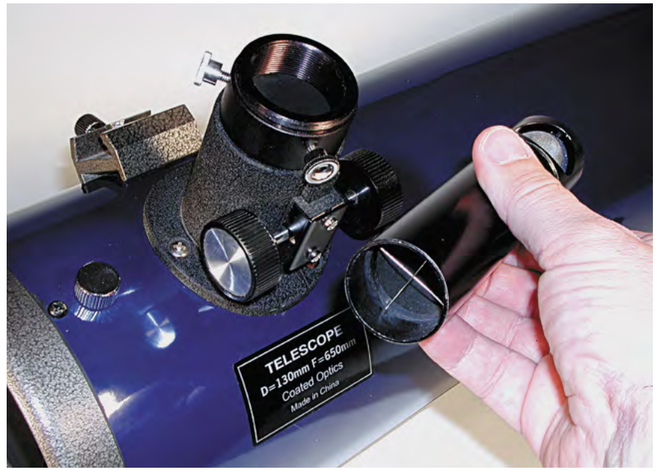
7. Once you have done this at medium power, switch to high power (200x to 300x). Any residual collimation error that remains after Step 6 will show up now, especially if you rack the star just slightly out of focus. Perform Steps 4 and 5 again, making even finer adjustments.

You can do this procedure to a fair degree of accuracy during the day. Sight a distant power-pole insulator, or piece of polished chrome trim. Look for a specular glint of sunlight—it can serve as an artificial star. For the final adjustment, use a star at night.

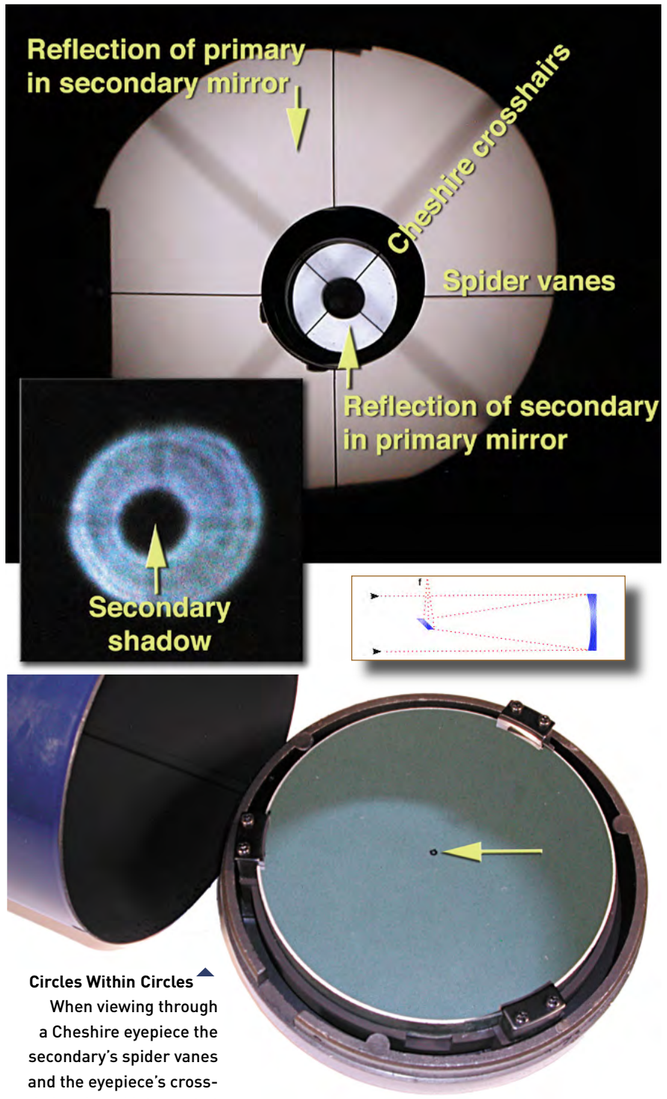
COLLIMATING NEWTONIANS

Both mirrors in a Newtonian are subject to adjustment, which complicates the process. But you can bring Newtonian mirrors into close collimation in the comfort of your home simply by examining the appearance of the various reflections while looking down the focuser. To do this, you need to make a "collimating eyepiece." Cut off the bottom of a plastic 35mm film canister, then drill or punch a small pinhole in the exact center of the lid (where the molding dimple is). This makeshift device keeps your eye in the center of the focuser tube.

An alternative is a collimation tool such as a Cheshire eyepiece, as shown above. Though more costly, laser collimators also work well and are worthwhile aids for keeping fast f-ratio Dobs in line. You adjust the mirrors so the laser's dot falls in the mirrors' centers and then reflects back on itself, hitting the bottom of the collimator.



Collimation Eyepiece
Cheshire eyepieces contain a small peephole (top) and an angled reflector for lighting up the secondary mirror. This model also contains crosshairs (shown at bottom) to aid in centering the optics. Suppliers such as Orion sell these tools. For more information on collimating Newtonians, see the June 2002 issue of *Sky & Telescope* magazine.



Circles Within Circles When viewing through a Cheshire eyepiece the secondary's spider vanes and the eyepiece's crosshairs should intersect at the center of the various reflections. In this case, the scope needs work, as revealed on a defocused star [inset] showing an off-center secondary shadow. A great help for centering optics is a black ink dot at the precise center of the primary mirror (bottom).

COLLIMATION PROCEDURE

1. The first step is to center the secondary or diagonal mirror. It should be in the center of the tube and directly underneath the focuser. This should rarely be necessary with new commercial scopes. To get it in the center of the tube, adjust the spider vanes so that they are of equal length—simple!

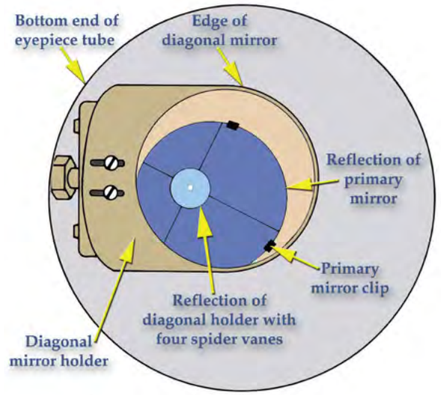
2A. To get the mirror directly under the focuser, turn the threaded rod that the secondary-mirror holder sits on. This moves the secondary up and down the length of the tube. Look into the focuser through your collimation eyepiece to see whether the secondary mirror is centered on the focuser hole. Do not worry about any off-center reflections in the diagonal mirror; just get the mirror itself positioned.

2B. Rotate the diagonal holder until the top of the holder is directly under the focuser (so that the diagonal is not turned away from the focuser tube). It is fairly easy to eyeball this. (On most new commercial telescopes, Steps 1 and 2 should rarely be necessary. However, homemade or used telescopes can have many collimation ills.)

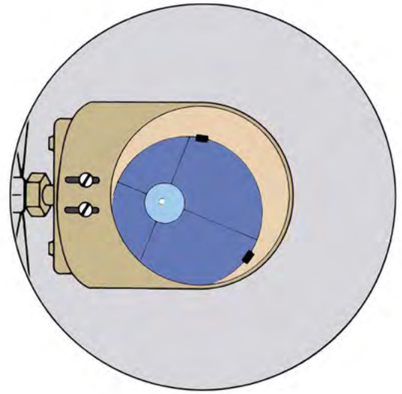
3. Adjust the tilt of the secondary mirror. This is where most Newtonian owners will need to start. To do this, adjust the three collimation screws on the diagonal holder so that the reflection of the main mirror is precisely centered in the diagonal mirror. For this step, ignore the reflection of the spider and secondary mirrors; just concentrate on getting the perimeter of the main mirror nicely lined up with the outline of the secondary mirror. Up to now, you have not touched the main mirror at all.

4. At this point, the main mirror's reflection of the spider and diagonal holder probably looks off-center. To bring them in line, adjust the three collimation screws on the main (primary) mirror cell. The dark diagonal-mirror silhouette should end up in the center of the reflection of the primary mirror, which itself is centered in the secondary mirror.

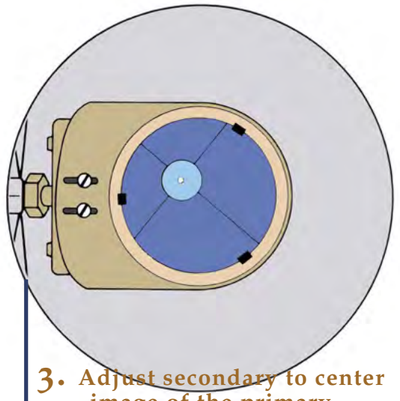
6. Once the coarse mechanical adjustments are made, take the telescope out at night and check the out-of-focus star images to see whether they are symmetrical. Wait for the telescope to cool down, then follow the same procedure outlined under Schmidt-Cassegrains but with a difference: use the three collimation screws on the primary mirror cell to do the final fine-tuning with a magnified star image. Do not adjust the secondary mirror. In future, it is the primary that you'll usually need to adjust.



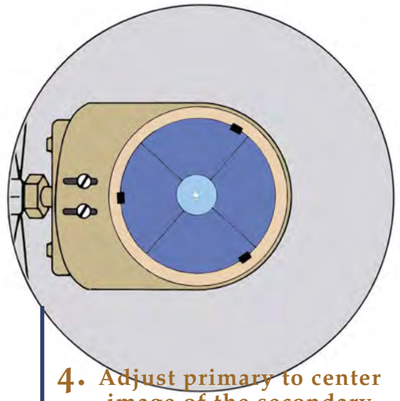
1. Optics out of collimation



2. Secondary positioned



3. Adjust secondary to center image of the primary



4. Adjust primary to center image of the secondary

Collimating a Newtonian The diagrams depict the view down the open focuser of a typical Newtonian.

STEP 1: Assess the situation. In this extreme case not only are the mirrors out of collimation but the secondary mirror is not even centered in the focuser.

STEP 2: Physically position the secondary. Adjust the length of the spider vanes and turn the diagonal mirror so it is centered directly under the focuser.

STEP 3: Adjust the secondary mirror's 3 tilt screws (bottom left). This may take a small Allen or hex wrench, perhaps in a metric size. The goal is to center the reflection of the main primary mirror so the final view looks like Step 3.

STEP 4: Adjust the primary mirror's 3 tilt screws. Loosening two may be needed so that the third can be tightened to provide sufficient tilt. The goal is to center the reflection of the secondary in the primary's reflection so the final view looks like Step 4. In this telescope, the collimation screws are behind a plate that must be removed first.