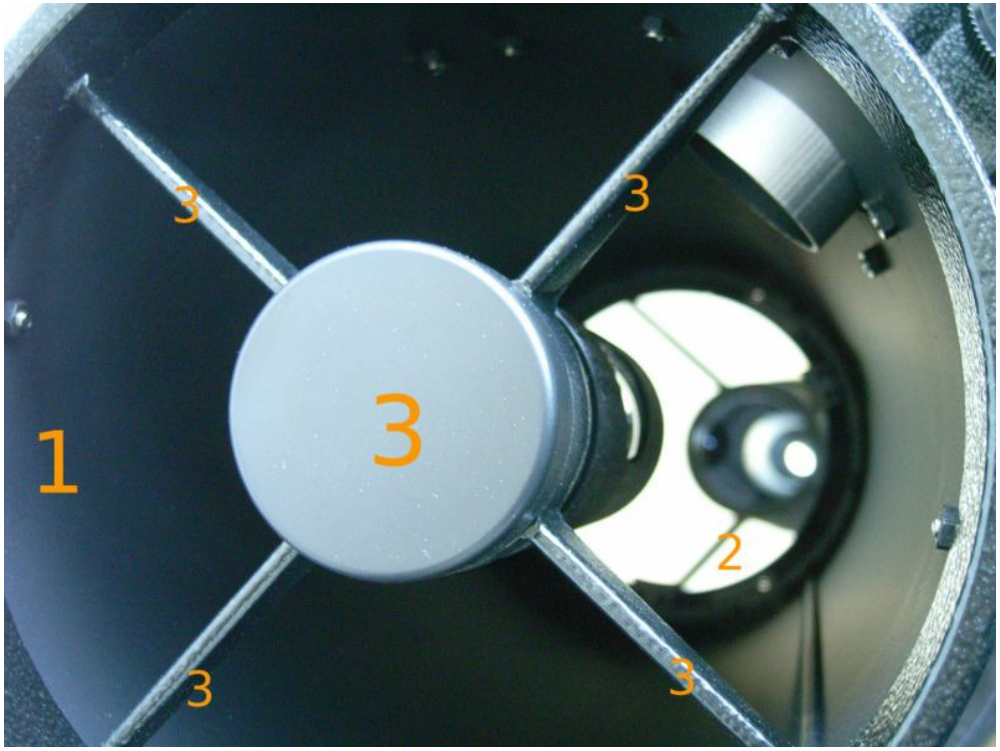
Collimating Newtonian Reflectors

Tools and Methods



Michael W. Masters

Image from Wikipedia Commons

Outline

- What is Collimation?
- Newtonian Reflectors
- Optics Adjustments
- Collimation Tools
- Collimation Steps
- Sources and References
- Question & Answer

Resources

Sources

See list of references and tutorials at end of presentation
Additional images adapted from: Kendrick Astro Instruments, Meade, Celestron, Orion Telescopes, Sky and Telescope, Astronomics, Tectron, and Starmaster Portable Telescopes

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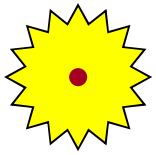
[Reference: http://www.law.cornell.edu/uscode/17/107.shtml]



Never point any telescope at the sun – unless it's a solar telescope, of course!! . . .and, don't look into the laser either!!

What is Collimation?

- Collimation is. . .
  - "To bring into line; make parallel" – *Random House*
  - "To bring into the same line, as the axes of telescopes" – *Webster's*
  - The process of precisely aligning the components of an optical system to the designed configuration
- A properly collimated optical system delivers the best image quality the instrument can produce
- Specifically, for Newtonian reflectors. . .
  - Collimation means aligning primary mirror, spider, secondary mirror and focuser (and thus eyepiece) to positions and orientations that cause light to follow the intended path
    - Spider, focuser and primary positions are usually fixed at factory
    - Primary tilt and secondary tilt and rotation may be readjusted each time

"...bad collimation is the number one killer of telescopes world wide..."
-- Walter Scott Houston

Why Is Collimation Needed?

- Components tend to become misaligned because of:
  - Manufacturing tolerances, component flexure, mechanical couplings, vibration and jarring, assembly variation, wear, temperature, scope orientation, etc.
  - Repeated transportation, assembly and disassembly, especially of truss Dobs
- The larger the scope, the more frequently collimation is required
  - Especially true of truss dobs, which must be reassembled for each setup
- The faster the primary's f-ratio, the more critical collimation becomes
- Component misalignment degrades performance
  - Misalignment can cause star image flaring, reduce contrast and even light gathering capability, and make it impossible to bring objects into focus

- Collimation is necessary for good performance – but to new scope owners it seems daunting at first

> *"The aberration known as* coma *is enemy number one for Newtonian reflectors — even a perfectly made mirror suffers from it*."
>
> – Nils Olaf Carlin, *Sky & Telescope*

Could You Collimate This. . . . . .With This?

Starmaster Portable Telescopes Owner
Rick Singmaster with Dob Truss Newtonian

Neither could I. . .
So I called Rick and said, “Help!”

by hand until the primary mirror reflection is centered laterally (top to bottom) on the face of the diagonal mirror. The diagonal holder should also appear equally centered top and bottom in the focuser tube—if it's not and the angle adjustment doesn't seem to be able to correct it, you may need to recenter the spider or resquare the focuser. Take your time and get this part right *now*, as you will rarely have to adjust the gross diagonal position again once you acquire perfect collimation. Secure the axial/rotational adjustment. See figures 2 and 3. If the angle adjustment is grossly skewed, the diagonal mirror will not appear to be round, and the axial/rotational adjustment will have to be tweaked again after the angle has been corrected. These two adjustments are closely related, and may require a few iterations to set properly.

The image of the primary mirror needs to be centered in the diagonal mirror (if the primary mirror has been removed, the diagonal mirror needs to be adjusted to point directly out the rear of the tube). If the diagonal needs angle adjustment, the screws on the rear of the diagonal holder (usually three screws) generate this motion.

Be forewarned that left-right tilting motion can be caused with these screws as well. Assuming the diagonal is more or less centered in the tube assembly, the motion we are attempting to effect will move the far point of the diagonal mirror (the edge of the mirror closest to the primary mirror) towards or away from the focuser *only*. For fine adjustment, look into the focuser and check to make sure that the image of the primary mirror is centered fore and aft (left to right) inside the real edge of the

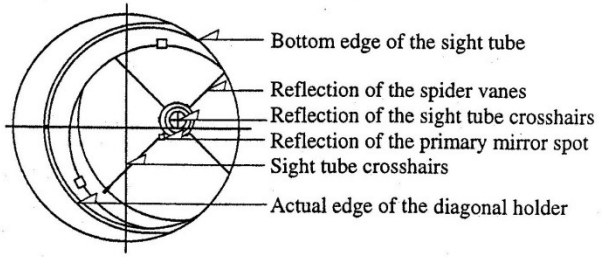
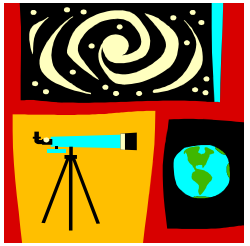


FIGURE 2

From *New Perspectives in Newtonian Collimation*, by Vic Menard and Tippy D’Auria (from Tectron), a 60 page (!) book on collimation!!

Collimation is Easy – Once you Know How!

- Collimation isn't hard – *if* the explanation is clear & concise!
  - In less than 10 minutes, Rick Singmaster explained where errors originate, what each collimation tool does, how to use it, and in what order to use each
- If you have trouble following your telescope's instructions or the many available tutorials and guides –
  - Find someone who can show you how to collimate your scope!
- *After you have successfully collimated your scope the first time it will never seem difficult again!*



> *"The presence of the diagonal mirror and the many confusing reflections make this adjustment the most difficult. . ."*
>
> – Harold Suiter, *Star Testing Astronomical Telescopes*

Newtonian Reflector Configurations

Collimation is similar for all Newtonian mounting types. What varies are the adjustments available on each scope and the toolset used to achieve collimation

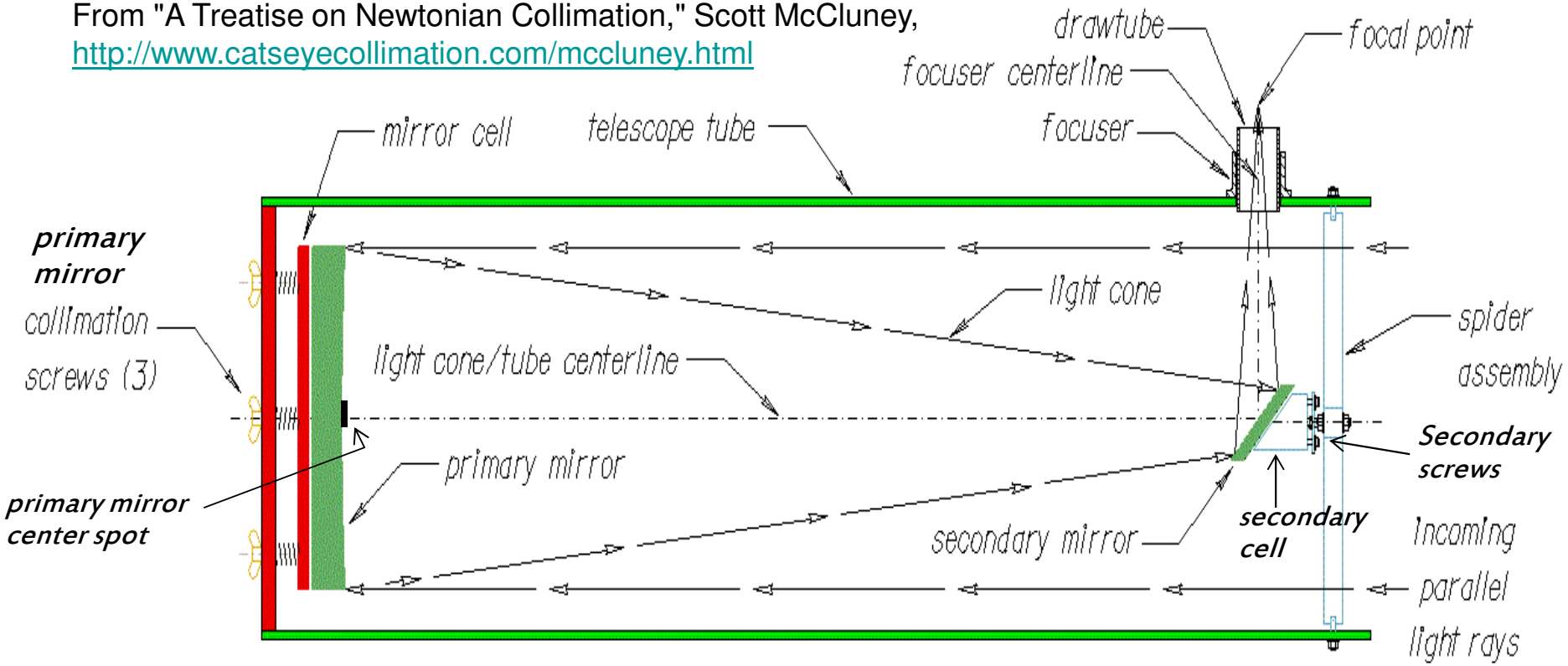
Equatorial-mounted
closed-tube Newtonian

Dobsonian-mounted
closed-tube Newtonian

Dobsonian-mounted truss Newtonian
(must be collimated every time)

Newtonian Reflector Optical Path

From "A Treatise on Newtonian Collimation," Scott McCluney,
http://www.catseyecollimation.com/mccluney.html



- Set at factory and/or rarely adjusted
  - Spider position & orthogonality
  - Focuser position & orthogonality
  - Secondary longitudinal position *
  - Secondary offset (via spider)
  - Secondary lateral tilt
  - Primary centering in tube

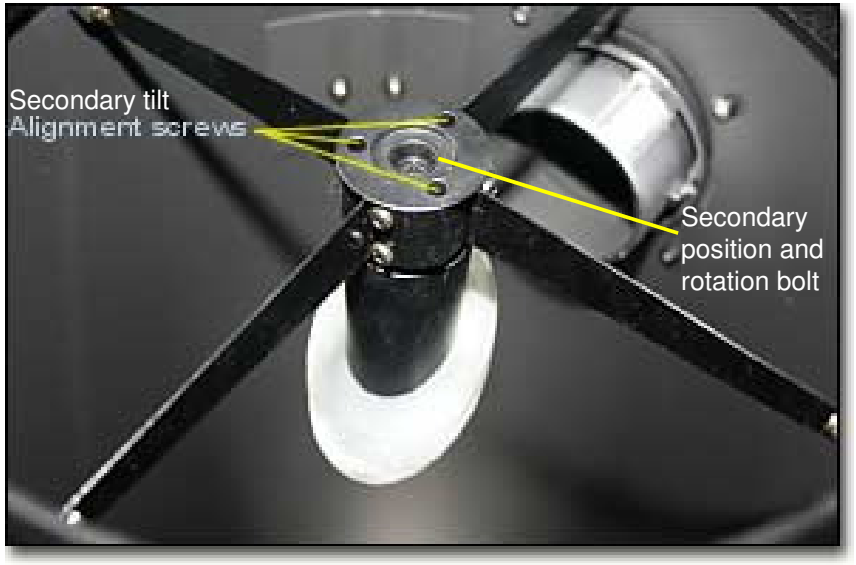
- Error sources likely to require re-collimation at each setup
  - Secondary mirror tilt
  - Secondary mirror rotation †
  - Primary mirror tilt

* Often included in directions for every setup

† Often omitted from directions – but vital!

What Can We Adjust?

Secondary mirror tilt and rotation



Primary mirror orientation

"How To: Collimate a Newtonian Telescope," Tim Trott, http://lonewolf-online.net/astronomy/tutorial/newtonian_collimation/

"Collimating my Dobsonian Reflector Telescope," Schlatter, http://www.schlatter.org/Dad/Astronomy/collimate.htm

- There are many variations in how secondary adjustments are implemented
- Without these adjustments it may not be possible to achieve perfect collimation unless they are set correctly at the factory and do not vary in use
- Do NOT overloosen secondary rotation and position bolt or it may fall onto primary!
- Adjustments not considered
  - Spider adjustment
  - Secondary offset
  - Focuser position

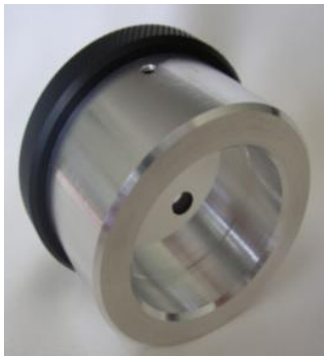
Common Collimation Tools

Sight Tube
w/crosshair
at bottom

1.25” Laser
w/ view window
(widely used)

2” Laser w/o
view window

Cheshire
Eyepiece

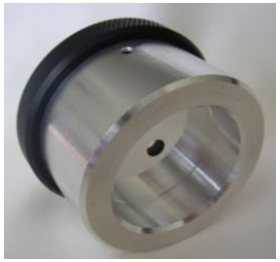


Autocollimator
w/ mirrored
inside surface

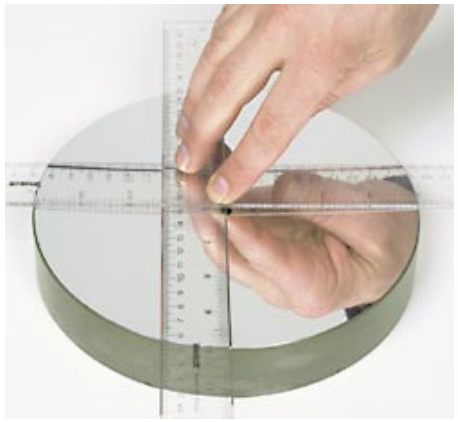
Not shown: Barlowed laser

There are many collimation tools and variants; these are a few of the more common and widely used tools.

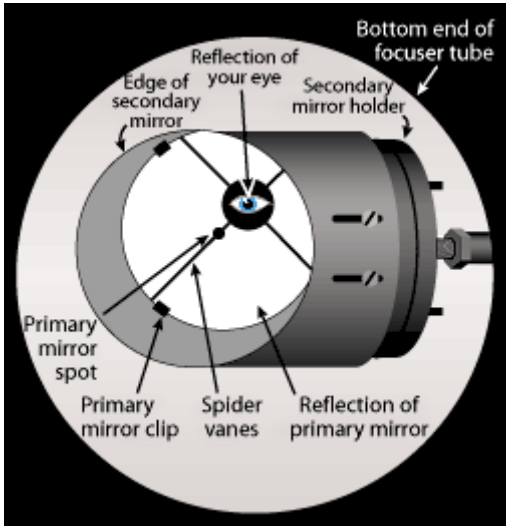
Use of Tools

				
Sight Tube	Laser with View Window	Laser w/o View Window	Cheshire Eyepiece	Auto-collimator
Initial evaluation & secondary centering	Secondary & primary mirror alignment	Secondary mirror alignment	Primary mirror alignment	Final optical path closure (secondary mirror)

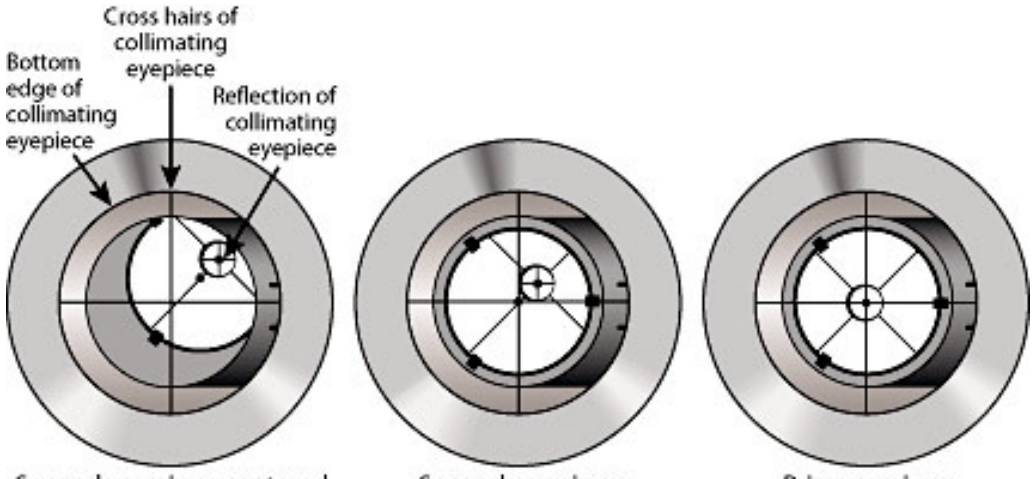
Collimation Views



Mark mirror center



View of uncollimated scope thru focuser or sight tube

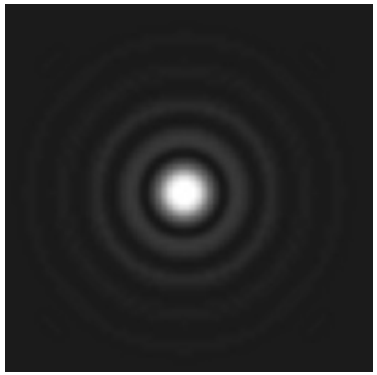


Secondary mirror centered under focuser tube
(Distance to primary set using sight tube)

Secondary mirror correctly aligned
(Tilt & rotation set using laser)

Primary mirror correctly aligned
(Primary tilt set using Cheshire or laser with view window)

Autocollimator image of residual misalignment (Secondary tilt & rotation)



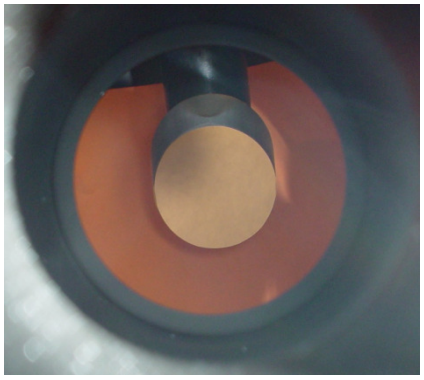
Star test

Images from various sources, see references

Collimation Steps

Version 1 – Using Laser w/View Window

- Use sight tube to center secondary mirror in focuser opening
  - Once centered, secondary position will rarely require readjustment
- Use laser and secondary mirror tilt and rotation adjustments to place laser beam on primary mirror center spot
  - Verify that laser return from primary intersects secondary before looking down tube, e.g. with sheet of paper
- Use laser and primary mirror tilt adjustments to align primary so that laser beam is centered in laser view window



From "Collimating my Dobsonian Reflector Telescope"
http://www.schlatter.org/Dad/Astronomy/collimate.htm

From "How To: Collimate a Newtonian Telescope," Tim Trott,
http://lonewolf-online.net/astronomy/tutorial/newtonian_collimation/

Collimating a Newtonian - Mozilla Firefox

File Edit View History Bookmarks Tools Help

http://www.andysshotglass.com/Collimating.html

Yahoo

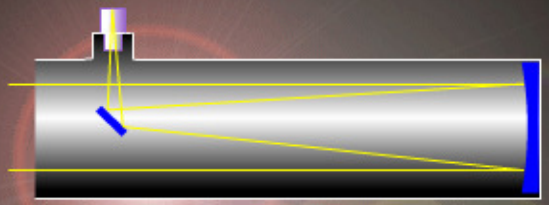
Andy's Shot Glass

Astronomy and Astrophotography for Non-Gazillionaires

HOME | GALLERY | ARTICLES | ABOUT ANDY'S SG | FORUM | PHOTO OF WEEK | WEBSTORE | KUDOS | SITEMAP

DEDICATED TO AFFORDABLE TELESCOPES AND ACCESSORIES

Collimating a Newtonian Reflector

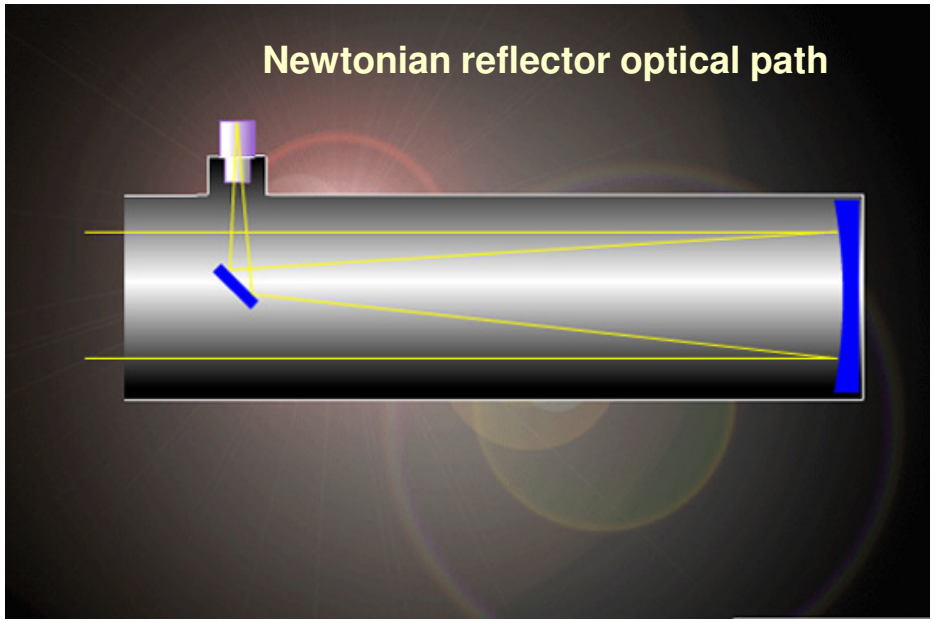


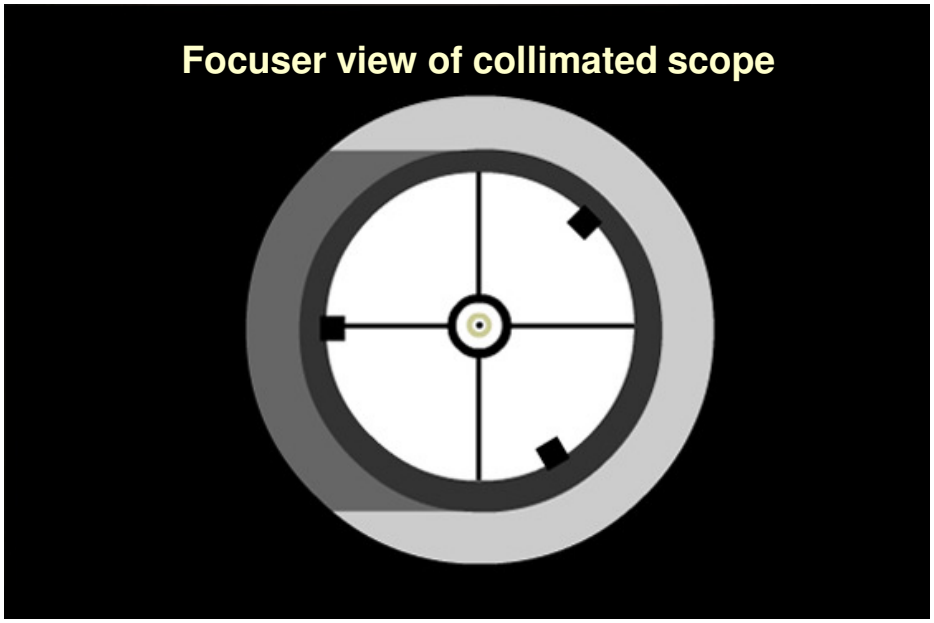
I remember the first time I looked through a collimating eyepiece and had no idea where to start. The instructions I got online were helpful, but not immediately so. I had to read them over and over to get an idea of what all the circles meant. This tutorial teaches two basic collimation techniques: Visual and Laser Collimating. Good luck on either or both.

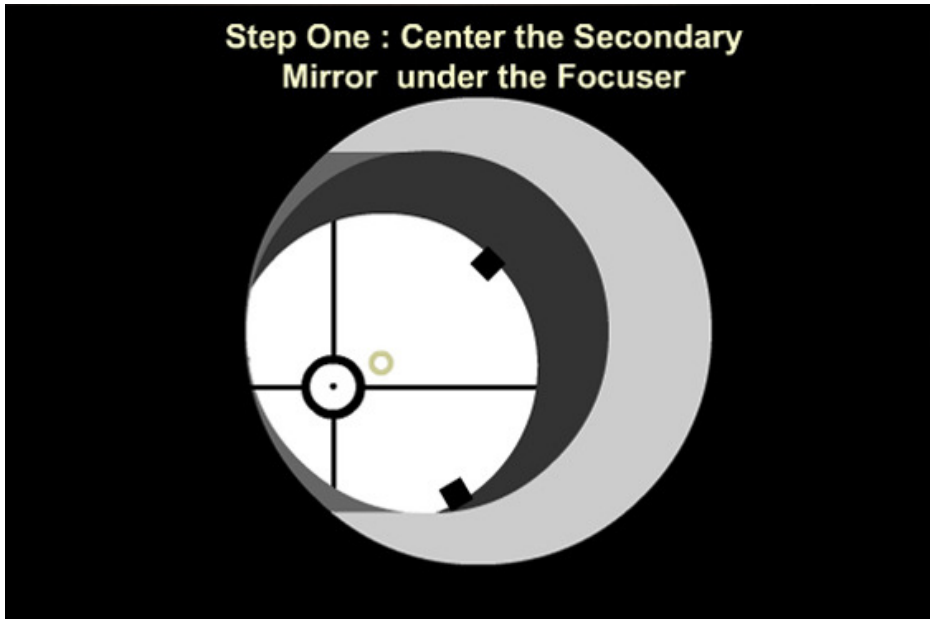
start movie

Done

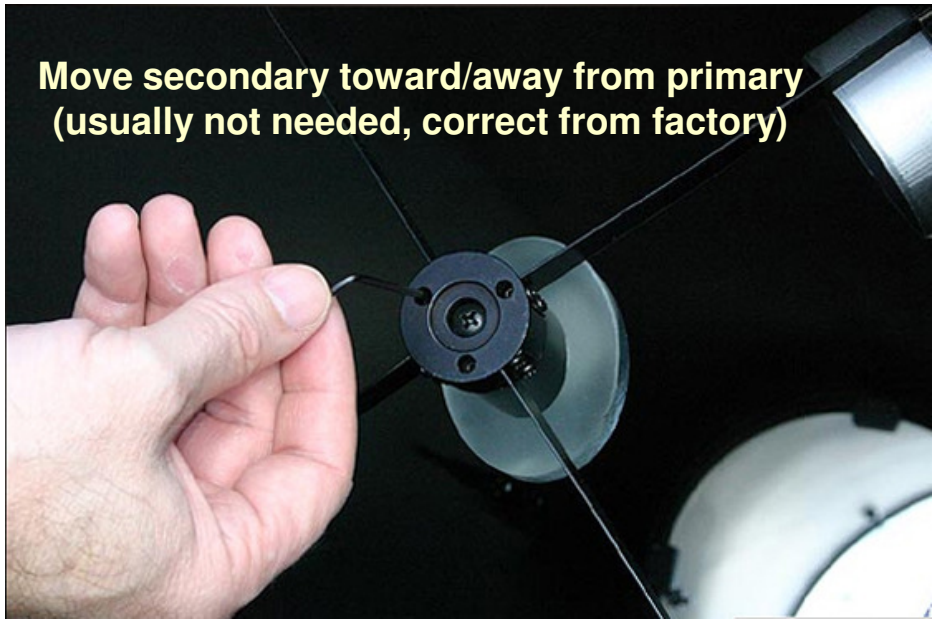
Collimation – Two Methods: Without Laser & With Laser

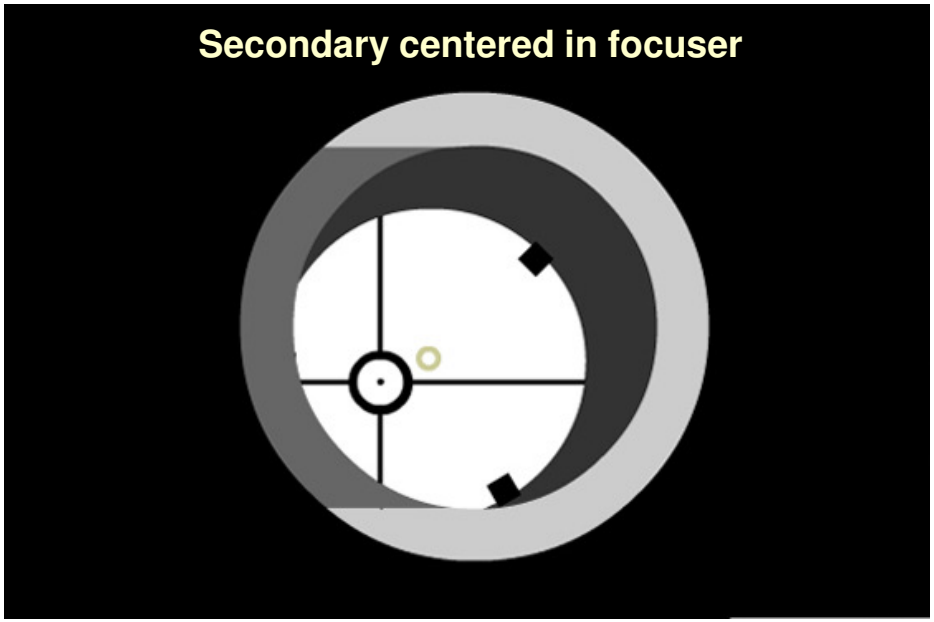




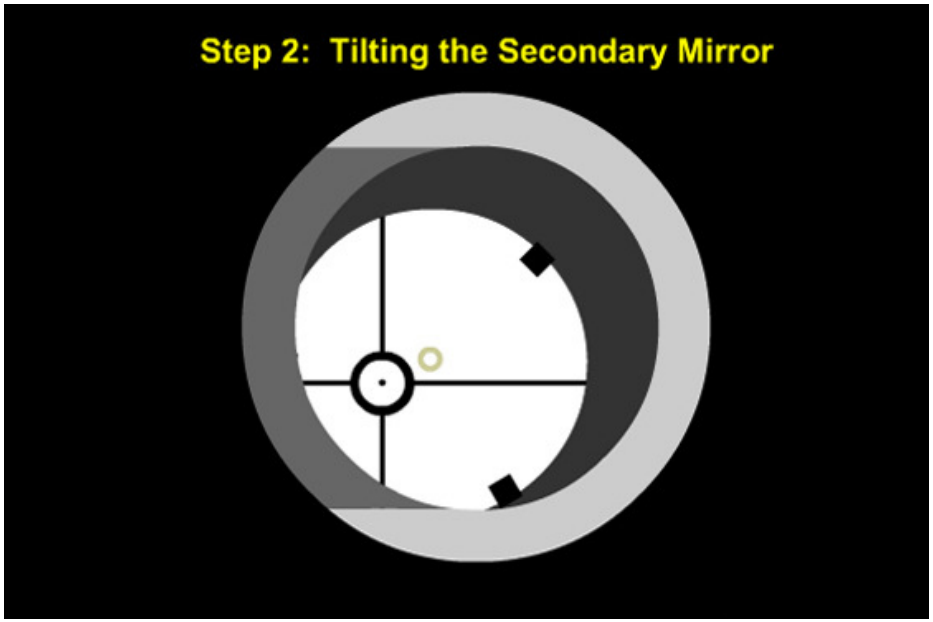


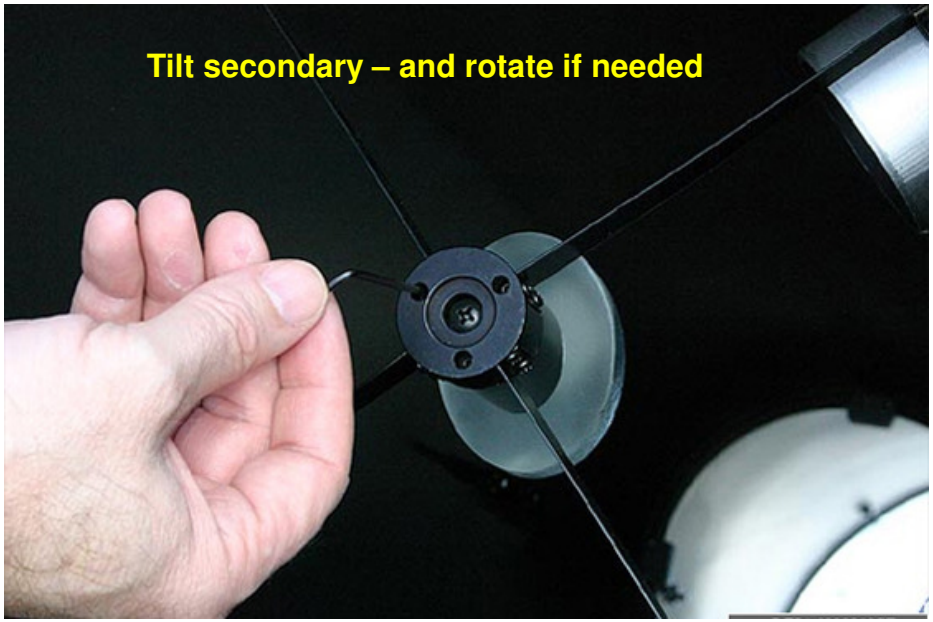
Collimation 1.1 – Center Secondary (no Laser)

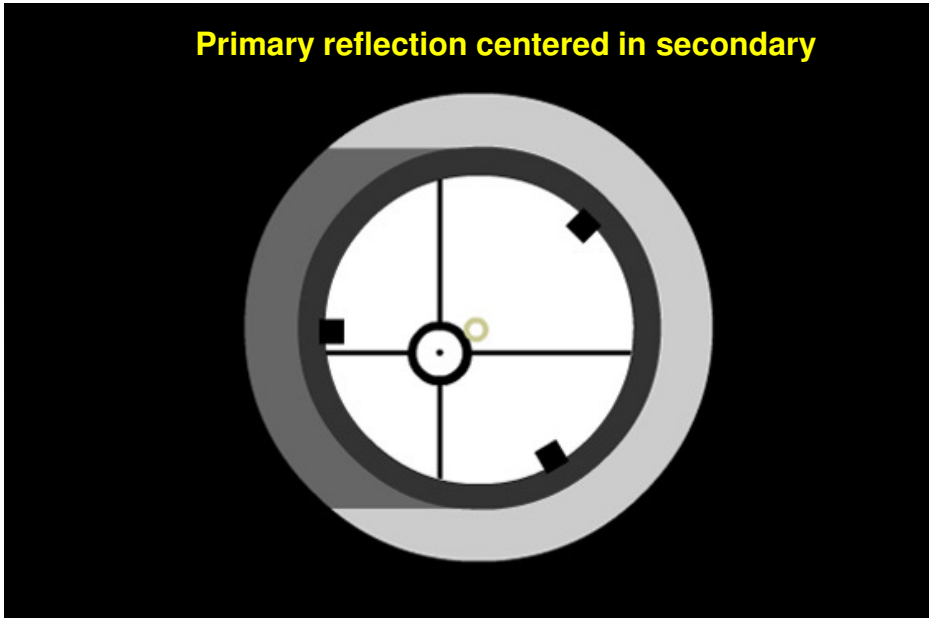




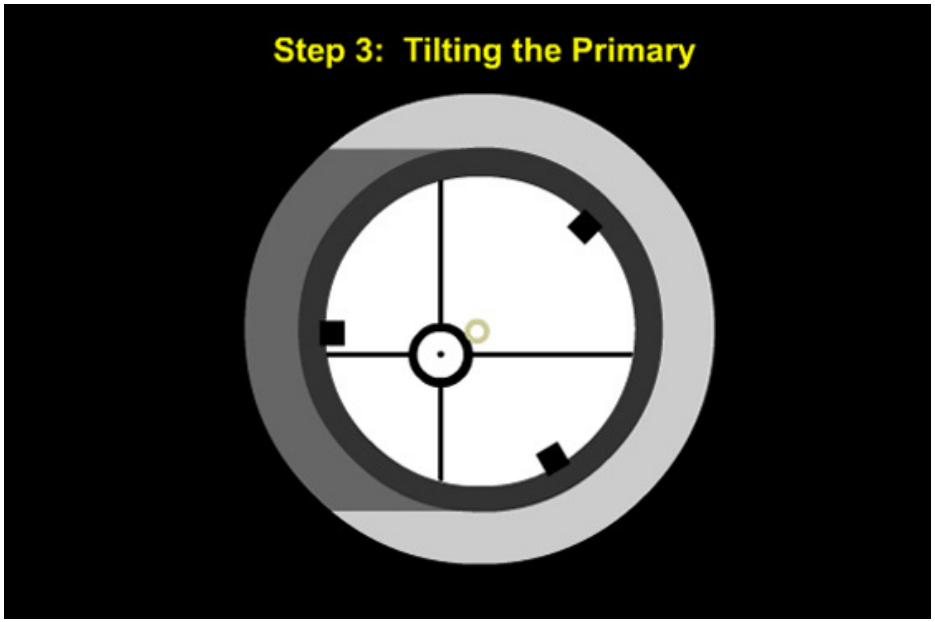
Collimation 1.2 – Tilt & Rotate Secondary (no Laser)

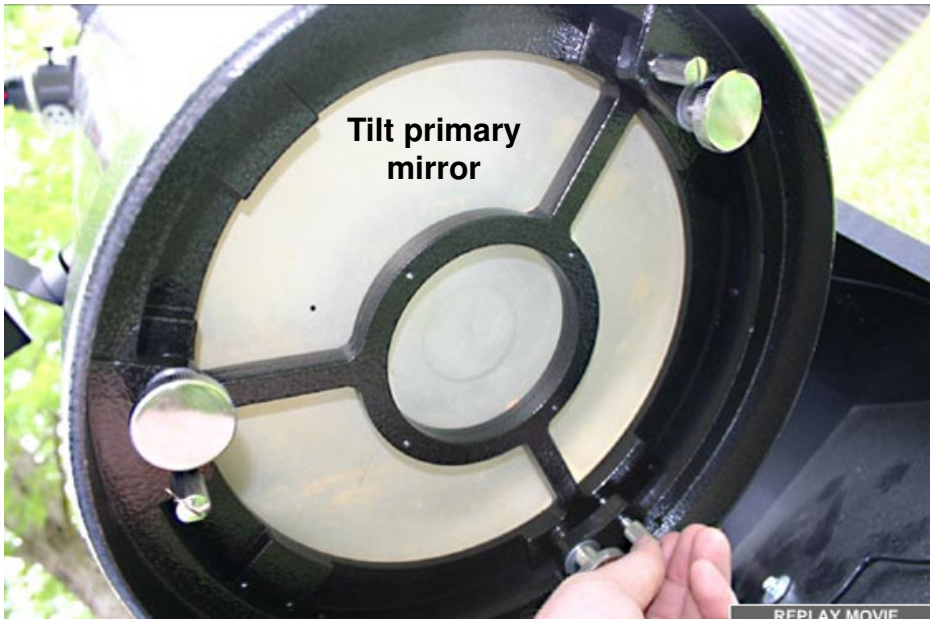


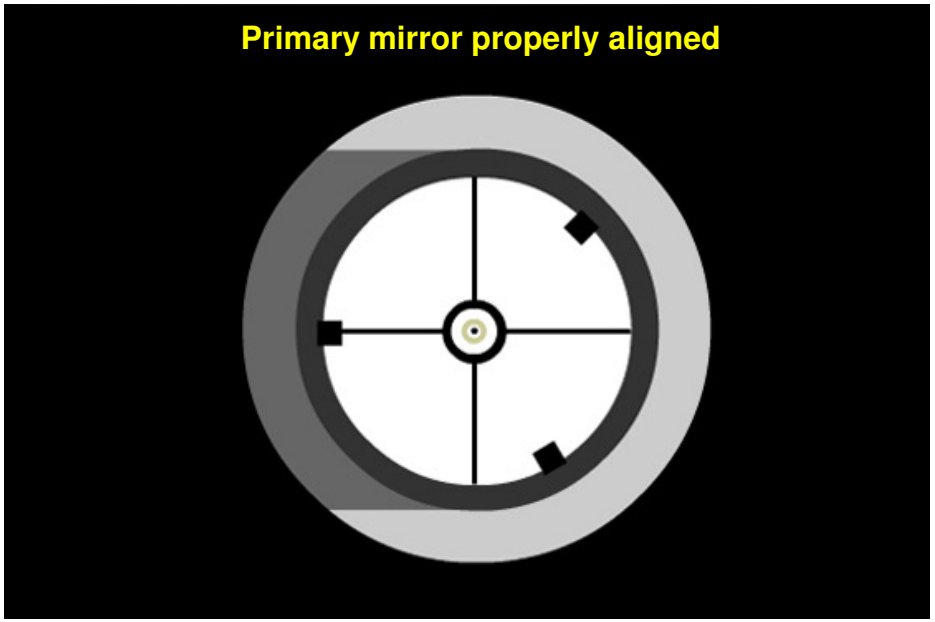




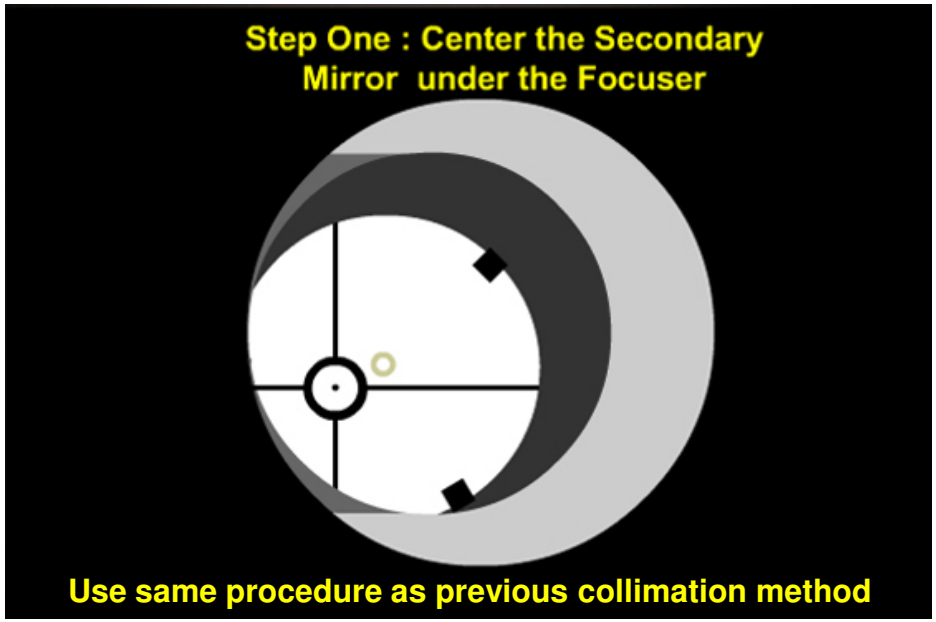
Collimation 1.3 – Tilt Primary (no Laser)

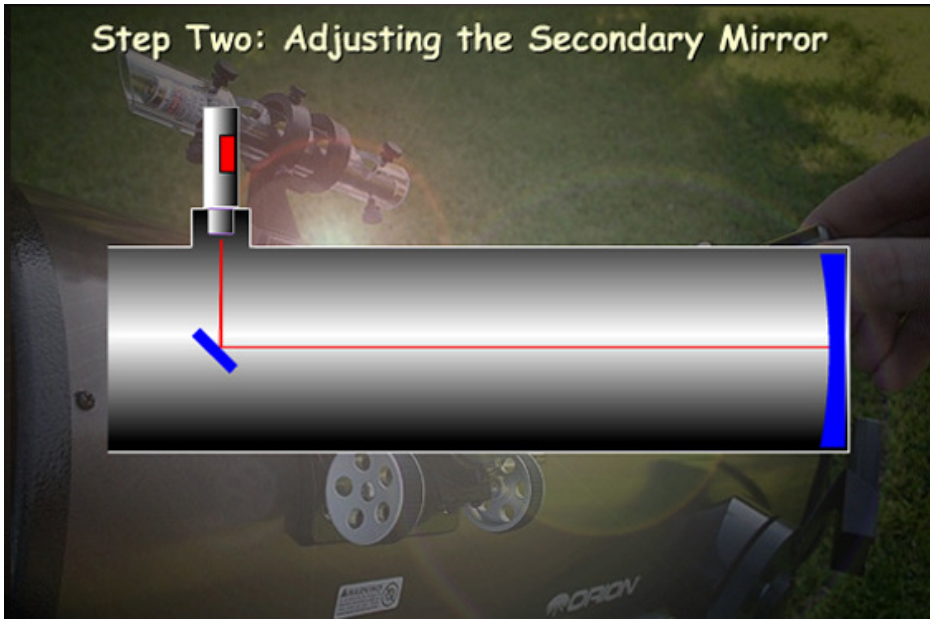


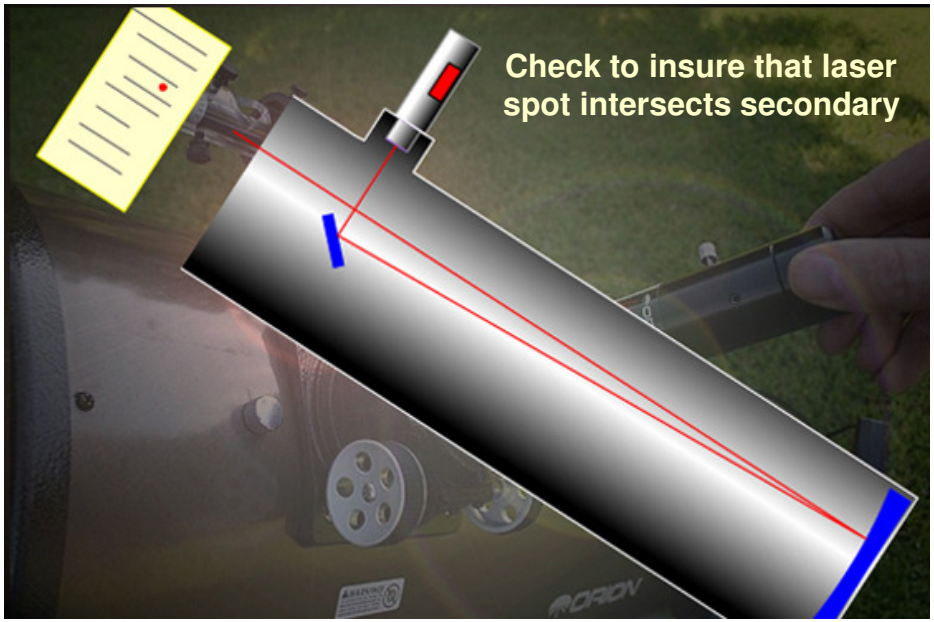




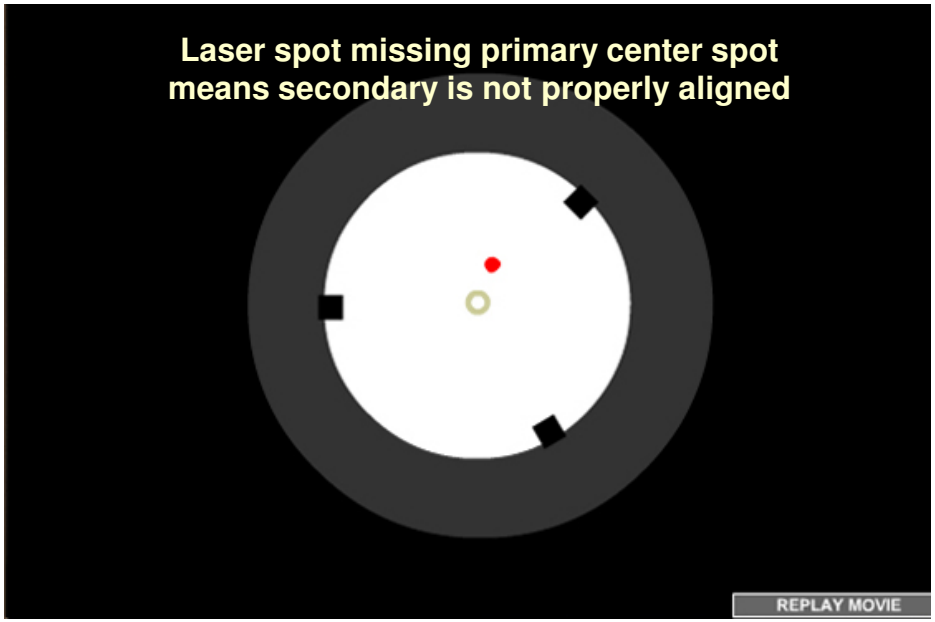
Collimation 2.1 & 2.2A – Laser w/View Window

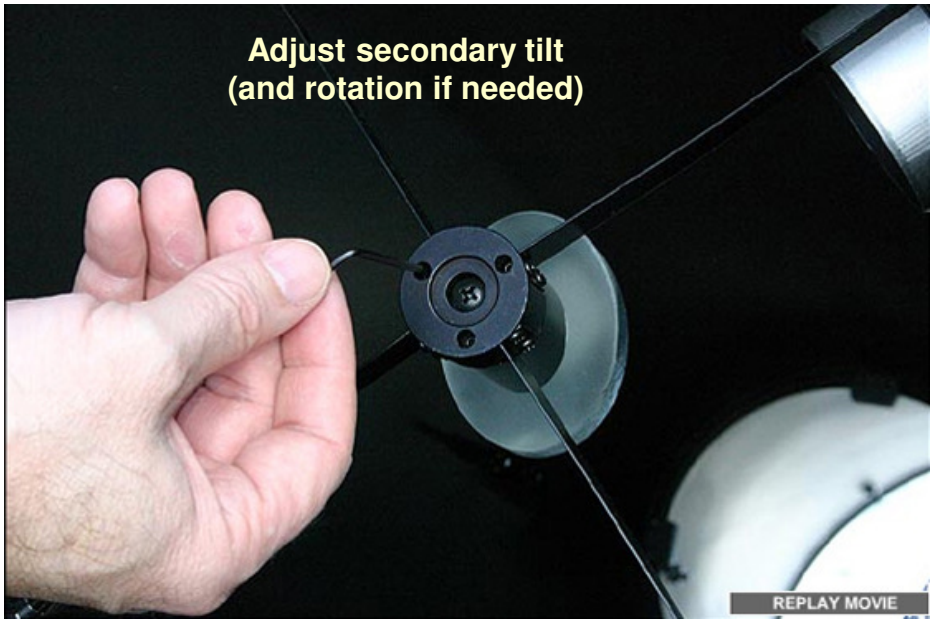


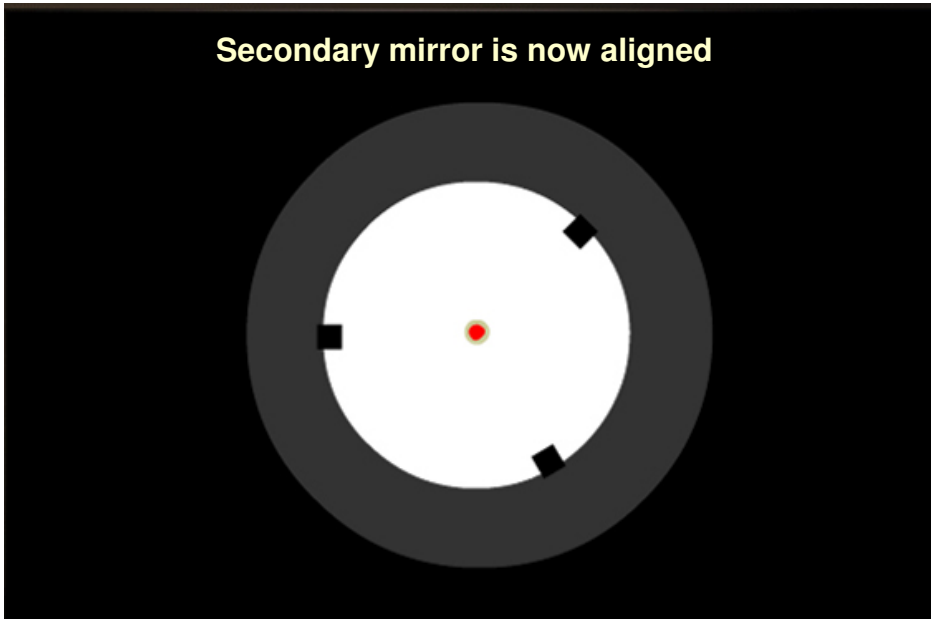




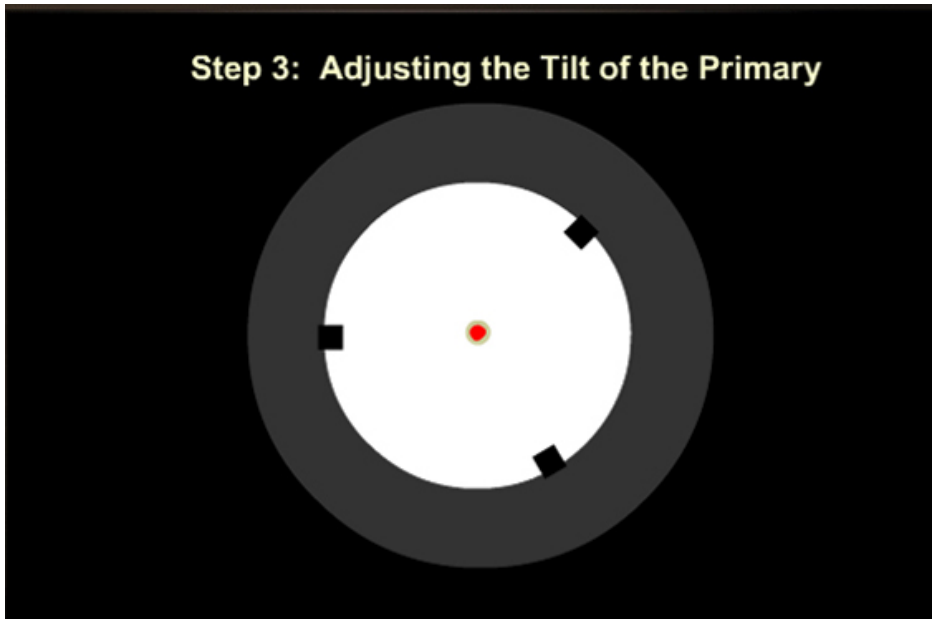
Collimation 2.2B – Tilt Secondary w/Laser

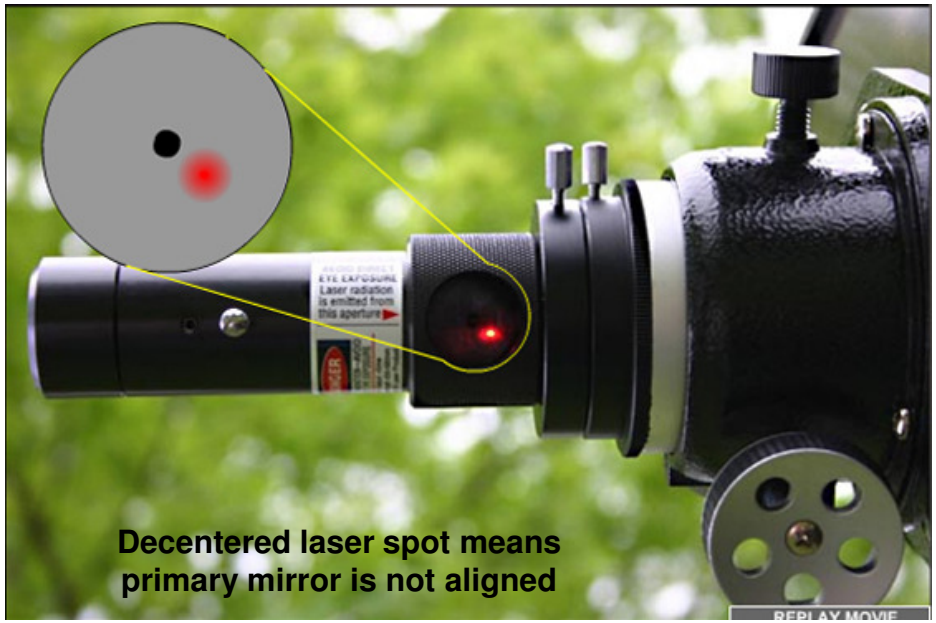


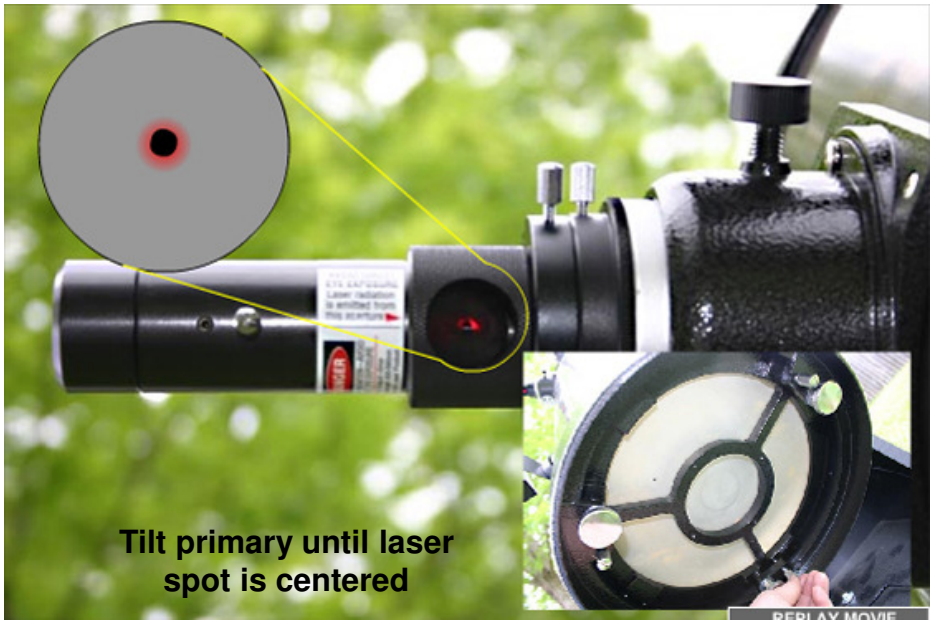




Collimation 2.3 – Tilt Primary w/Laser







Collimation Steps

Version 2 – Using Laser w/o View Window

- Mark center of primary mirror with collimation spot or ring
- Use sight tube to center secondary mirror in focuser opening
  - Once centered, secondary position will rarely require readjustment
- Use laser w/o window to precisely align secondary mirror by tilt (to/from focuser) and rotation adjustments
- Use Cheshire eyepiece to precisely align primary mirror
- Iterate previous two steps if required
- Use autocollimator eyepiece to completely close optical path
  - Final secondary mirror adjustment
- Perform star test to verify collimation

Cheshire & autocollimator work best under a bright sky (twilight or earlier)

Collimation References and Tutorials

- "How To: Collimate Your Newtonian Reflector, Nils Olof Carlin -- highly regarded article from Sky & Telescope
  - http://www.skyandtelescope.com/howto/diy/3306876.html
- "FAQ About Collimating A Newtonian Telescope," Nils Olof Carlin – details about types of alignment errors
  - http://www.backyardvoyager.com/collimationFAQ.html
- "The Autocollimator and its Reflections," Nils Olof Carlin -- explanation of the autocollimator and its use
  - http://web.telia.com/~u41105032/Acoll/Acoll.html
- "Some Collimation Myths and Misunderstandings," Nils Olof Carlin -- more good info from Nils Olof Carlin
  - http://web.telia.com/~u41105032/myths/myths.htm
- "Collimating a Telescope: Newtonian Reflector," Starizona – good tutorial for laser with many illustrations
  - http://starizona.com/acb/basics/using_collimating_newt.aspx
- "A Primer on Collimation of Newtonian Telescopes," John Crilly -- Cloudy Nights tutorial using a side window laser
  - http://www.cloudynights.com/documents/primer.pdf
- "A Primer on Collimation," by Tom Clark -- collimation without a laser from the makers of Tectron collimation tools
  - http://www.amateurastronomy.com/collimate.html --
- "Collimating a Newtonian Reflector," Andy's web site -- good movie using collimating cap and laser with side window
  - http://www.andysshotglass.com/Collimating.html
- "How To Collimate a Newtonian Telescope," Tim Trott -- article based on collimating cap and laser with side window
  - http://lonewolf-online.net/astronomy/tutorial/newtonian_collimation
- "A Treatise on Newtonian Collimation," Scott McCluney -- good tutorial defining terms and describing tools
  - http://www.catseyecollimation.com/mccluney.html
- "Collimating my Dobsonian Reflector Telescope," Schlatter -- collimation without a laser
  - http://www.schlatter.org/Dad/Astronomy/collimate.htm
- "How to Collimate Your Newtonian Reflector," Joel Gonzalez -- simplified tutorial using collimating cap and laser
  - http://www.backyardastronomy.net/collimating_newtonians.html
- "Collimation with a Barlowed Laser," Nils Olof Carlin – Sky and Telescope article on the Barlowed laser
  - http://gmpexpress.net/~tomhole/blaser.pdf
- "Barlowed Laser Collimator," Kendrick Astro Instruments – fact sheet from Kendrick
  - http://www.kendrickastro.com/astro/pdf/barlowed_laser_collimation.pdf
- "Adventures in Collimation," by Bryan Greer – discussion of secondary offset
  - http://www.fpi-protostar.com/bgreer/collim.htm & http://www.fpi-protostar.com/ftp/techp2.pdf

Final Thoughts

Invest in good tools and learn how to use them – it will pay great dividends in image quality and satisfaction with your scope.

Star parties are a great place to share information and get hands-on help with collimation.

Demonstration and Q&A