Adjustment (Collimation) of Newtonian Telescopes

with the help of the

LASER-COLLI™ MARK III (Order No.: 2450343)

by Baader Planetarium



Instruction Manual

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Adjustment of Newtonian Telescopes with the Laser-Colli™ by Baader Planetarium



Caution: LASER !

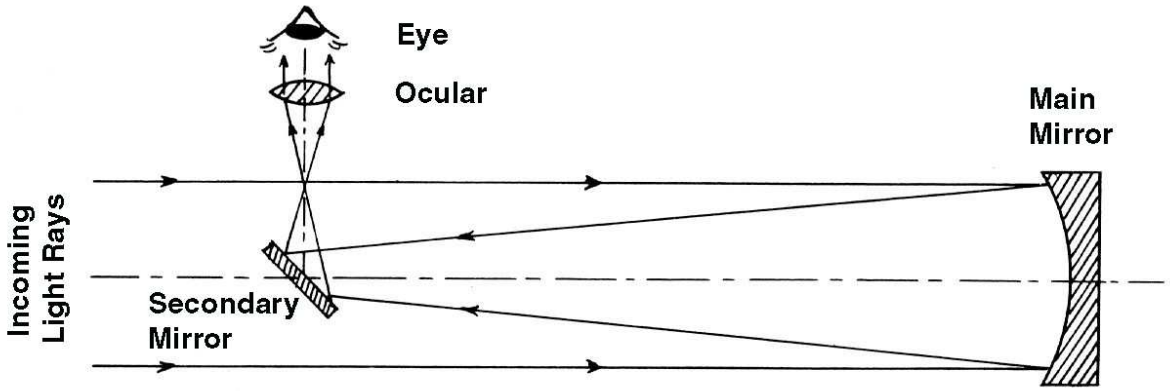
Never ever look directly into a laser beam! Protect your eyes!!
Store the Laser-Colli™ carefully so that it cannot be reached by children or **inexperienced adults**. Consider that a heavily Miss-aligned telescope will deflect the laser beam out of the tube In an unpredictable direction possibly without you being aware of it.

Colli is the abbreviation for collimation.
In our context collimation is the alignment of the optical system so that the focal plane of the telescope meets the focal plane of the eyepiece squarely.
Collimation is critical for good optical performance of your telescope.
Accurate collimation can be the difference in seeing or not seeing the Great Red Spot and shadow transits of Jovian moons on Jupiter

Generally Newtonian telescopes are considered susceptible to a loss of image quality (collimation) if, for instance, they are jarred or bumped, during transport by car etc. If this is a situation that you have come across then a **Laser-Colli™ MARK III** will be a basic accessory to keep your telescope performing at it's best. With a little preparation and a bit of practice your telescope will be correctly collimated within a minute or two.

A Newtonian telescope can provide you with excellent images of astronomical objects – but only if the primary mirror (concave parabolic mirror at the rear end of the tube) and the flat secondary mirror (catching and deflecting the light out to the side of the tube and into your eyepiece) are correctly aligned with each other and additionally centered on their optical axes.

Let's have a look again at the light path of a Newtonian telescope.



Lightpath in a Newtonian Telescope

The incoming light *travels first from left to right to the main mirror at the end of the tube, is reflected there and travels right to left, to the secondary mirror, which in turn deflects the light out of the tube and – via the eyepiece – into your eye.*

Loss of collimation is an important factor to be aware of with telescopes of any design if performance 'falls off' at any time.

A refractor's eyepiece tilted within its eyepiece holder will show the same low quality blurred images. This holds true with all other mirror telescope systems like the popular Schmidt-Cassegrain or Maksutov systems.

The following will guide you mainly through the collimation of a Newtonian telescope.
At the end we shall consider Schmidt-Cassegrain systems and other catadioptric instruments.

If misalignment exists in a Newtonian telescope the main image error - 'so-called' coma – will be enlarged greatly and is even visible at the center of your field of view whilst normally it can be seen only at the edges.



Please note: The larger the diameter of the main mirror and the shorter the focal length of the optical system, the more the telescope is affected by a small loss of collimation.
As an example: A Newtonian with a main mirror diameter of 200 mm and a focal ratio of f/10 (2000 mm focal length) is less influenced by a slight misalignment; a Newtonian with 400 mm diameter mirror and a focal ratio of f/5 (same 2000 mm focal length) however is 4 times more affected by the same collimation error .

*Picture above shows **coma error**, strongly exaggerated.*
Thermal turbulences blur the image to a "small comet's trail".

The following procedure assumes a mass marketed telescope for collimation.
Owners of homemade mirror telescopes will need to know how to collimate.

To obtain best results from collimation:
The focuser (eyepiece holder) must be orientated exactly 90° vertically to the tube.
1.)The main and the secondary mirrors must be centered in the tube.

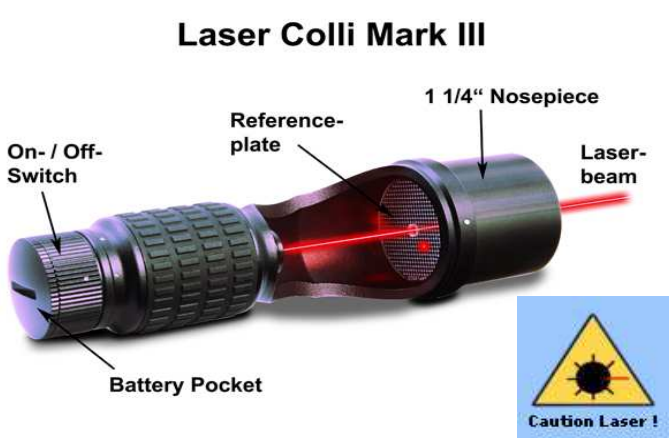
Mass marketed telescopes should fulfill both requirements. The correct center of the main mirror is (nearly) always guaranteed by the mechanical construction of the main mirror's cell within the tube. The secondary mirror often can be adjusted slightly in its center position via three or four of its vanes. With a newly bought system you can assume a correct center position. If it is not centered this does not result in a loss of quality of the image in any case but your field of view might become darker.

What is the function of our Laser-Colli™?

The principle is simple. The normal eyepiece (ocular) is removed and the **Laser-Colli™ MARK III** is slid into the eyepiece holder and switched on. The laser beam hits the secondary mirror and is reflected back to the main mirror, from where it is reflected again to the secondary mirror and then back into itself through the eyepiece holder. If either or both of the mirrors are displaced from the optical axis of the telescope system, the laser beam cannot be reflected into itself.

If the beam is reflected into itself your Newtonian system is perfectly collimated.

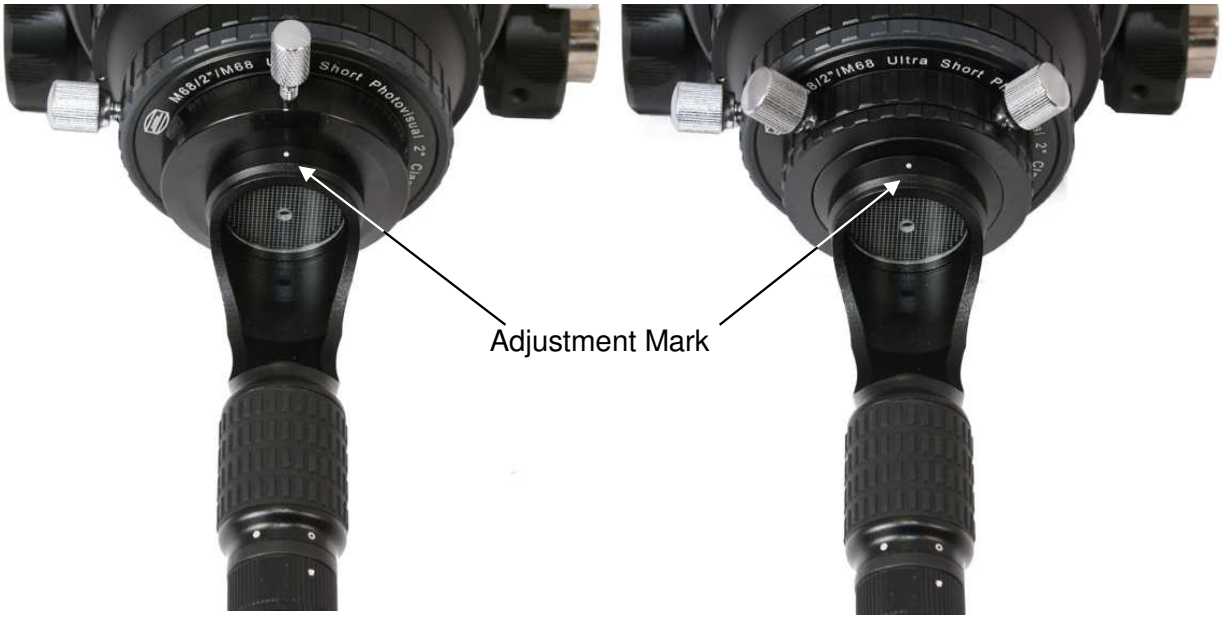
More often than not, this is not the case – and collimation is necessary.



Of course, the **Laser-Colli™Mark III** functions reliably only if the laser beam itself leaves its own housing in an absolutely centered position.

Therefore the laser source is symmetrically adjustable in the housing around its rotational axis, which has been carefully adjusted on a mechanical lathe by us prior to shipping. There is no need for further adjustments of the Laser-Diode.

Orientation of the Laser-Colli™ in the eyepiece holder
All our **Laser-Colli™ Mark III** instruments are individually adjusted in an eyepiece holder on a lathe for the required centered rotational symmetry. Necessary mechanical production tolerances for the ocular holder and the housings of our **Laser-Colli™Mark III** instruments require a correct orientation when mounting the **Laser-Colli™ Mark III** into your eyepiece holder as shown below.



Please see the picture on the left:
The white mark on the Laser Housing (adjustment mark) should be aligned with the locking screw on the ocular holder. If your telescope has two or more locking screws 120° apart of each other, the white mark must be orientated on a center line just between them (see picture on the right).

The **Laser-Colli™ Mark II**I will be switched on by a 30° rotation of the on/off-knob at the rear end of the housing. The laser beam passes through the small hole in the center of the glass reference. The reference has been etched with a very fine grid.



On Left: Clear, translucent **Reference plane** with etched cross-marks

Most laser collimating devices use a simple opaque piece of plate glass to act as indicator for the returning laser beam.

Many small suppliers just scratch the glass by using sand paper in order to get a cheap opaque reference plane.

Our Clear Reference plane is **etched** (not printed!) with hundreds of tiny crossmarks so that the returning beam lights up in the ever so tiny grooves of each individual cross that is being touched by the laser light.

Not only does this produce a much more concentrated dot, the main benefit is the fact that our reference plane is <u>not</u> opaque!

Whenever your optical system is just slightly misaligned, it is no problem to immediately recognize the reflected laser beam on the glass reference plate.

But what happens when you don't see any reflected dot at the reference plate due to a moderate de-collimation of your optics?

In the case of an opaque reference plate the returned laser beam will not be visible at all and you will be unable to view the returned beam in the focus tube.

The clear reference plane of the **Laser-Colli™ MARK III** will allow viewing down the focuser tube through the etched plate, and in most cases it will be possible to glimpse a reddish glow were the laser beam grazes the focusing tube internally.

That is the reason for placing the glass reference plate as near as possible towards the focuser and to design the body of the **Laser-Colli™ MARK III** in a way that makes it easy to look almost straight into the focus tube from behind.

Step-by-step procedure to collimate your Newtonian telescope

1. Mark the geometrical center of your primary mirror.

Remember the important requirement that the laser beam touches the primary mirror centrally – exactly in the middle of your center mark.
If the secondary mirror is tilted only slightly out of its necessary 45° angle against the ocular holder, the laser beam will not be reflected down towards the center of the main mirror.

Therefore you should prepare your system for the first (and all following) collimation(s) by marking the geometrical center of the main mirror.
This requires, in Newtonian telescopes with a closed tube, removing the main mirror cell from the tube. The removal results in the need for re-collimation afterwards of course, but this is done with the **Laser-Colli™ MARK III** in no time.

Read your telescope instruction manual for the correct procedure to remove the main mirror cell. Most manuals contain this in the maintenance part "Cleaning The Main Mirror". Nearly all designs hold the main mirror cell in the tube by three screws. You will find them near the rear end of the tube spread 120° apart around the tube's circumference. Prior to any removal **mark the position** of the main mirror cell against the tube with two small sticky labels. Then carefully unscrew these three screws and pull the main mirror cell out of the tube very cautiously.

Now make a stencil of cardboard using compasses and scissors.
The stencil's outer diameter has to match exactly that of the main mirror.
Cut a hole of 8 to 10 millimeter diameter exactly in its geometrical center.
Place your stencil exactly above the main mirror and copy the inner edge of the small hole directly onto the main mirror with a waterproof marker, resulting in a circle marked on the main mirror (see next picture).
Though often mentioned in the literature, a black spot marking on the main mirror's center is useless! You would blacken out that part of the mirror surface that is needed for the laser beam to be returned to the **Laser-Colli™ MARK III**.

This circle mark is hidden behind the secondary mirror and therefor has no influence whatsoever on the imaging capability of the primary mirror.

Relocating the primary mirror:

Carefully replace the main mirror cell back into the tube to its previous position using the stickers to locate. Replace screws etc.

The collimation procedure of a Newtonian telescope with pictures.

Step 1

Collimation always starts with a control and adjustment of the secondary mirror.
Following pictures show the view from the tube's front end directly onto the main mirror.



Picture 1 left shows the laser beam (red dot) obviously missing the marker circle in the center of the main mirrror. Note the three adjustment Hex head screws of the secondary mirror spread 120° apart. Very cautiously and only in small steps re-tilt the secondary mirror by very slowly tightening and releasing these adjustment screws.
While you look directly onto the main mirror watch the laser's light dot moving into the center marker circle while you are adjusting the secondary.

Picture 2 below *shows first success:*
The laser's light dot is correctly centered within the marker circle.



Most telescope constructions adjust the secondary mirror by three loaded screws like those (allen head screws) shown here in the picture.
In other words: Turn one screw slowly clockwise and the secondary mirror is tilted in the direction towards this screw.
When the laser's light point is centered correctly in the marker circle, successful adjustment of the secondary is achieved.

Step 2

Possibly the main mirror's optical axis might be additionally tilted against that of the secondary mirror. Please observe the reference grid of the **Laser-Colli™ MARK III**. If you see the reflected laser light point already somewhere on the grid pane (next picture below) you are closing in on final success. The final action is to tilt the main mirror so as to make the laser beam reflected into itself and re-pass through the small hole in the reference plate.

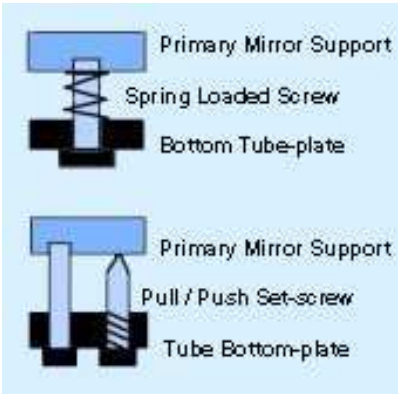


If you see this on your reference plane, adjust (tilt) your main mirror in a way that the laser point passes exactly through the center hole thus being reflected into itself.



Now your Newtonian optics are perfectly collimated.

Remember to switch off the Laser Colli whenever you don't need it, otherwise the batteries will be exhausted very quickly.



Adjusting (tilting) the main mirror of a Newtonian is (nearly) always done either by three single screws or by three pairs of screws both of which being spread 120° apart.
Details are shown in the sketch .

When there are only three single screws (upper sketch) the tilt of the main mirror is effected by spring-loaded screw.
Once more: Turning one of the screws clockwise tilts the main mirror towards this screw.

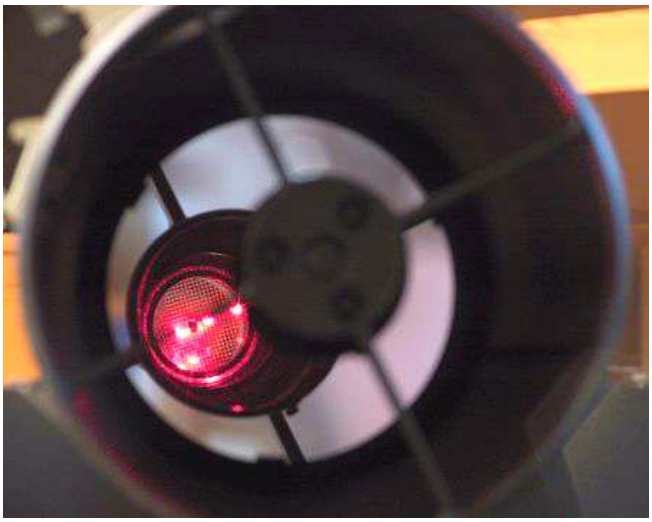
On most larger Newtonians, 3 pairs of push/pull screws are used (lower sketch).
In the lower sketch the left side screw is threaded into the mirror support plate and will pull that side down, the right hand screw has it's thread cut into the bottom plate and would lift the mirror up.

The spring loaded mirror support is easier to manufacture and to work with. On the other hand the resilience of the springs can change with temperature and age, resulting in frequent loss of collimation of the main mirror. Therefore springs are used only in smaller Newtonian telescopes. Adjustment by push/pull screws are a little more costly to produce and more elaborate to work with but they guarantee practically no movement of the main mirror's adjustments due to knocks and vibrations (transport). They are therefore mainly used in larger telescope systems with the larger weight of the main mirror.

Adjustment of the main mirror is done best by two persons. While you are turning the main mirror's adjustment screws your friend would be reporting about the movement of the reflected laser light beam.

Case 1:
The main mirror of your Newtonian may be out of adjustment quite a bit.
This may result in no success in step 1 above, i.e. you don't see the reflected laser beam on the reference plane at all. In this case cautiously glance through the grid towards the secondary mirror. With a little bit of luck you will see somewhere at the inner walls of the eyepiece holder the grazing reflection of the laser beam. If you see it, adjust the main mirror first to bring the laser beam's light point onto the grid – continue the adjusting operation until the beam is centered on the grid, showing full collimation.

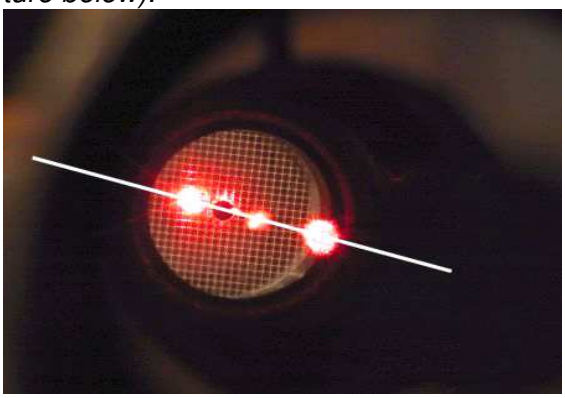
Case 2:
You don't see any reflection of the laser beam at all – well, your system is a long way out of adjustment.
Again your **Laser-Colli™** can help.



Picture above *again shows the view from the tube's front to the reflected images of the secondary mirror and the grid plane.*

First look into the tube front down to the primary.
On the main mirror you see the reflection of the secondary mirror and the reference grid. In the grid plane itself you see many reflected images of the laser dot.

If *these reflected images are not orientated in a straight line but spread, as in the picture left, you have to adjust the main mirror in such a way to line them up in a straight line (see picture below).*



If the red reflections are exactly orientated in a line the main mirror is well adjusted already (white line shown in the picture serves only for clarification).
Having the reflected laser beam showing safely on the grid plane you can finish the collimation process quickly.







Tilt the main mirror with the help of the adjustment screws until the laser beam passes through the hole (and is reflected into itself).
That's it! Your Newtonian is perfectly collimated. A final check of the collimation has to be done with a star image (see below).





Picture left *shows the coma error in a heavily misaligned Newtonian – highly enlarged and exaggerated.*

Picture right *shows a star image also highly enlarged after collimation (highly idealised as well).*

Adjusting Schmidt-Cassegrain (SC) telescopes with the Laser-Colli™ MARK III.

Adjusting SC-Optics by means of a laser is not an easy task.

Reason being – other than in an Newtonian optical system – the SC-secondary mirror is shaped strongly convex thereby dispersing the beam of most common lasers into a blob or otherwise odd-shaped form, rendering it unusable for defining the actual center of the reflected laser beam.
It takes a careful selection of lasers and a special technique for sharpening the outgoing laser beam, in order to perceive a sharply defined round laser signal, when reflected from an SC-secondary mirror.
Another, most important help in this task are the hundreds of crossmarks, etched into the reference plate of the **Laser-Colli™ MARK III**. They glow much more strongly compared to a simple opaque glass, making it a lot easier to perceive the center of the reflected laser beam.

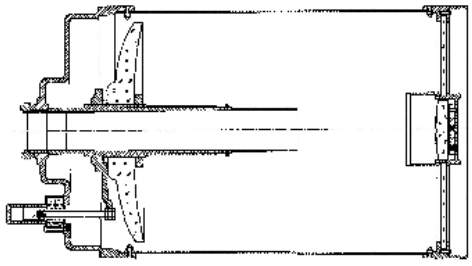

Laser-Colli™ Mark III
used on Celestron
Newton Telescope


Laser-Colli™ Mark III
used on Celestron
CPC SC- Optic

The alignment procedure itself is exactly the same as for a Newton optics – only much simpler.

Fasten the **Laser-Colli™ MARK III** straight into the SC-visual back, without using a star diagonal, in order to avoid wrong alignment due to inaccurately tilted mirror diagonals.
Arrange the on/off contact of the **Laser-Colli™ MARK III** to line up with one clamp screw of the visual back, alternatively halfway between – whenever there are two locking screws to be found.
Inspect the reflected laser beam on the reference plane – center the laser beam to fall back into itself by tilting the secondary mirror, accessible from the front end of the optical tube.





Simplified sketch of the SC-secondary mirror tilting mechanism. Three screws are arranged 120° apart, around a center pin on which the secondary mirror pivots.
Loosening one screw and tightening another will tilt the mirror into the designed position.

WARNING

Loosening all three screws completely will make the secondary mirror fall off its support – possibly falling down onto the primary mirror and creating severe damage!

Only attempt to collimate your SC-Telescope after having read fully the corresponding section in the original instruction manual.

A word of caution when collimating SC's and other Catadioptric OTA's:

In any Newtonian telescope it is a commonly accepted procedure, to mark the center of the primary mirror with a small circle, before attempting collimation.
It is "**The**" most important action in order to ensure control over the process of collimation (Aristotle's: "Give me a fixed point in space and I will unlatch the earth from it's path").

In terms of an SC-optical system, this would mean to mark the very center of the convex secondary (!) mirror, so as to ensure the laser beam stays within the rotational center of the optical system.
The downside is that most visual back accessories in present day SC-OTA's are made so sloppy that the precondition mentioned above will not be met.
Even with the best tools – a sufficiently sharp and well adjusted laser beam with a precision chrome sleeve, you must ensure that the laser will hit the SC-secondary dead center, so that the reflected beam will truly indicate the offset of the secondary adjustment, rather than the offset from the secondary's center.
Putting a tiny center "ring"-mark onto a secondary is not a difficult task, when the SC-OTA has a provision to quickly un-mount the secondary mirror – such as it is the case with CELESTRON'S FaStar-Optics.
The procedure is essentially the same, as described earlier for the center mark on a Newtonian primary.

In any case – if you do not feel happy with marking the secondary mirror of your telescope, please stick with the "real star" collimation techniques as described in the manual of your Schmidt-Cassegrain telescope.

We cannot take any responsibility for damaged optics sets due to careless or otherwise wrong optical handling.

Changing batteries

If the batteries are worn-out after a while or you may have forgotton the swich off your **Laser-Colli™ MARK III** after the last collimation, the batteries must be changed.

Simply unscrew the endcap on the on/off switch counterclockwise approximately three turns to open the battery compartment. Remove all three SR 41 Batteries and replace them against three round "hearing aid" batteries 1.5V, such as **Maxell- or Camelion LR 41.** The "MINUS"-side must face the bottom of the battery-compartment.







Note:
The diameter of the exiting laser beam almost matches the diameter of the small hole in the reference glass.

For this reason it is possible that the beam slightly lights up on the rim of the center hole.

This has no negative effect whatsoever on precision or functionality
of our **Laser-Colli™MARK III.**

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