



**RC, UltraCRC, RiDK, RiLa, RiFast, RH "Veloce"  
Telescopes – All models**

# **USER MANUAL**

Rev 2.0 – March. 2016 – download the latest version of this manual from [www.officinastellare.com](http://www.officinastellare.com)

EVEN BEFORE YOU TOUCH YOUR TELESCOPE, *PLEASE*

# READ CAREFULLY

- **General notes, in this page.**
- **CHAPTER 2 – "WHAT IS IN THE BOX" and**
- **CHAPTER 3 – "HOW TO HANDLE THE TELESCOPE"**

If you handle the telescope in a wrong way, you could damage it, and such damage is NOT covered by the warranty.

## General notes about all telescopes:

- **Never use your telescope to look at the Sun, or even near the Sun.** Severe eye damage or even permanent blindness may result.
- Always cover your telescope in daytime (or keep the dome closed).
- Never leave the uncovered telescope unattended in daytime.
- Do not use *Officina Stellare* telescopes even *to project* the image of the Sun. Pointing the Sun may produce serious damage to the telescope. Secondary mirror, secondary mirror support or internal electronic parts may be damaged (or even set on fire!) simply by the STRONG heat produced by the primary mirror when pointed to the Sun.
- NEVER use Herschel prisms or eyepiece filter. NEVER!!! Any *Officina Stellare* telescope is far too big for such devices.

- If you want to observe the Sun, use a professional filter, placed IN FRONT of the telescope. A 15 cm (6”) off-center Astrosolar filter is a good and cheap solution.
- If you search planets or bright stars in daytime, pay great attention before to put your eye to the eyepiece, if the telescope points near the Sun.
- In daytime don't look into the telescope while it slews to target.
- Truss structure telescopes may be "dangerous" during daytime because the open structure allows the light to enter also laterally. Always use the provided black elastic cover.

***Officina Stellare* is not responsible for any damage related to improper use of the telescope.**

**INDEX**

Chapter 1 – Introduction.....	Page 4
Chapter 2 – What is in the box.....	Page 7
Chapter 3 – How to handle your telescope.....	Page 8
Chapter 4 – Electronic controls.....	Page 9
Chapter 5 – Collimation.....	Page 15
Chapter 6 – Collimation from scratch .....	Page 19
Chapter 7 – The RH "Veloce".....	Page 33
Chapter 8 – Care and cleaning of your telescope.....	Page 37

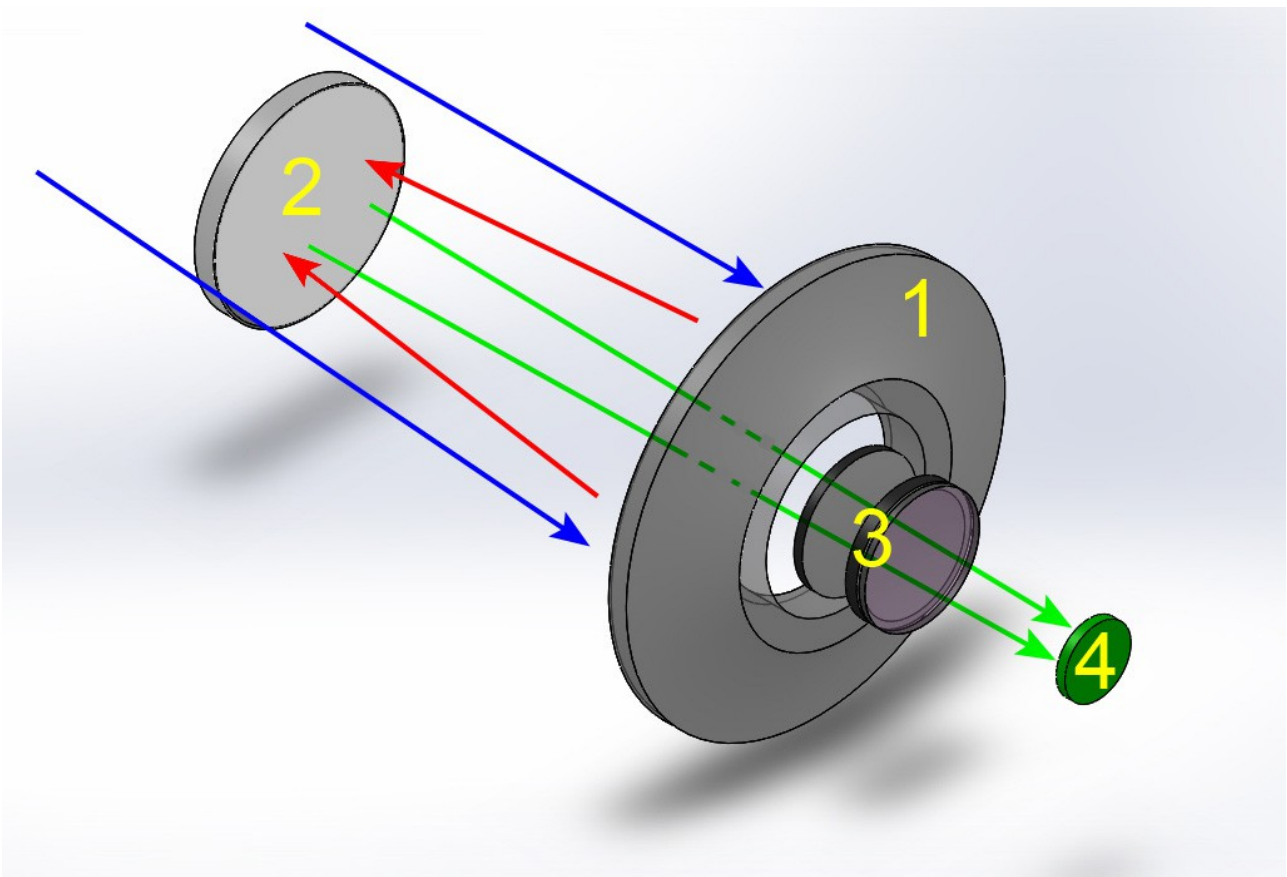
## CHAPTER 1: INTRODUCTION

**Congratulations for your new telescope!** Any detail of your *Officina Stellare* telescope, from the primary mirror to the smallest screw, has been designed, machined and assembled to achieve the best possible results, under any condition, both for astronomical or non-astronomical uses.

We used the best materials, the best CNC machines, and decades of experience to deliver simply a real state-of-the-art instrument, to satisfy both professionals and the most demanding amateur astronomers. From the optical, mechanical and electronic point of view. Each *Officina Stellare* telescope, and any piece of optics (mirror or lens) is 100% designed and figured in Italy\*, in our optical shop in Occhiobello (near Ferrara) and in our assembly plant in Sarcedo (near Vicenza).

We appreciate your feedback. Should you have any comment about your *Officina Stellare* instrument, please let us know. Send your suggestions or criticisms (also appreciations are welcome, of course) to [support@officinastellare.com](mailto:support@officinastellare.com). We are proud to build great telescopes, because we love astronomy. For our efforts toward perfection, only the sky is the limit.

### HOW DOES IT WORK?



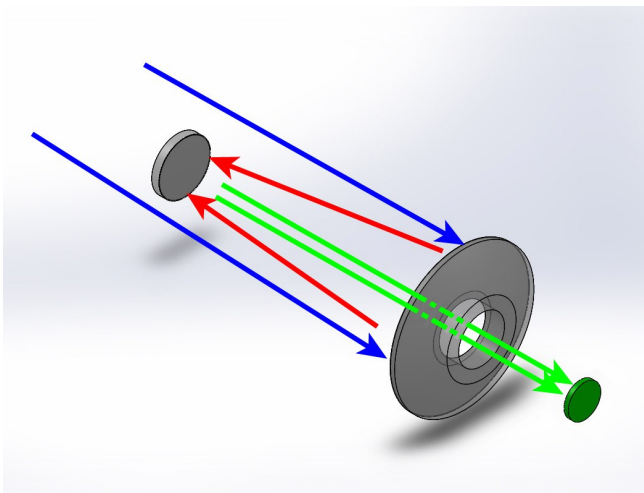
The figure above represents **UltraCRC**, **RiDK**, **RiLa** and **RiFast** telescopes. They all look very similar, but:

- **UltraCRC** telescopes are modified Ritchey–Chrétien, with a 2-lens corrector group near the focal plane (but the secondary mirror is hyperbolic, like in "traditional" RCs).

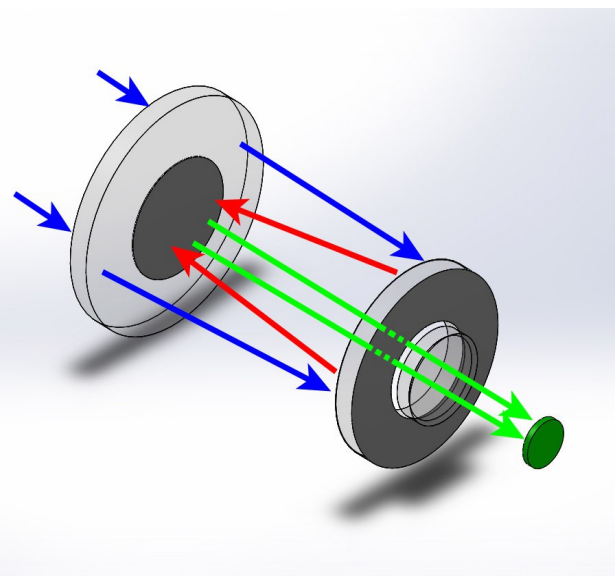
- **RiDK** telescopes are optimized Dall-Kirkham, with a 2-lens corrector and a spherical secondary mirror.
- **RiLa** and **RiFast** telescopes, are based on different "tuning" of the Harmer-Wynne scheme. Like in the RiDK the secondary mirror is not hyperbolic, and this allows a bit "relaxed" tolerance on collimation. The lens corrector group has 3 elements.

Anyway, in all such telescopes the light coming from the sky (blue arrows) is focused by the primary, concave mirror (1 & red arrows) on to a divergent secondary mirror (2). The secondary mirror reflects again the light through a hole in the primary mirror, where a 2 or 3 lens corrector is located (green arrows and 3). The image forms at the focal plane (4) where a detector (or an eyepiece) is placed. The unique shape of mirrors and lenses, and a sophisticated system of light baffles provide a focal plane that is reflections-free, well illuminated, wide and flat. All telescopes provide, at the focal plane, a star spot size that is much *smaller* than almost *any* CCD/CMOS pixel. Obviously the shape of mirror/lenses and their spacing is different in each model, to achieve the best optical performance for a given aperture and focal ratio.

**RC** and **RH "Veloce"** telescopes are a bit different. In the RC series, a "pure" Ritchey–Chrétien design, there is no lens group before the focal plane and the secondary mirror is hyperbolic (figure at left). This is in theory the "best" and simplest solution for deep sky imaging (many professional giant telescopes, including the Hubble Space Telescope, are Ritchey–Chrétien) but can't be done with low (i.e. "fast") f/ ratios. The size of the aberration-free focal plane is smaller than in other schemes, and collimation is really critical.



The **RH "Veloce"**, on the other hand, is the most complex optical scheme used by *Officina Stellare*, but it is simply the best solution for wide field photography, and it is the only really new scheme for telescopes to enter production in decades! You see it in the figure below. In RH telescopes, there is a meniscus front lens that is *weakly* convergent, and the primary mirror is a "Mangin" mirror (from the name of its French inventor). A Mangin mirror is a mirror that is coated on the *back* surface, not on the front. The light passes through the glass, is reflected by the coating and then passes again through the glass. For this reason, a Mangin mirror is called a refractive-reflective optical element, and opens exciting possibilities to optical engineers. This complex design includes also a corrector group before the focal plane, achieving performances impossible otherwise, with extraordinary "fast" photographic performances over wide focal planes. We called our RH telescopes "Veloce" because this word, in Italian, means *fast*. A curiosity about RH telescopes: since the meniscus (frontal lens) is *convergent*, the Mangin mirror is *smaller* than the "nominal" diameter of the scope, while the meniscus itself is *bigger* than the nominal diameter, to ensure a good illumination over the wide field of view of such scopes. For example, the 200 mm model has a 220 mm meniscus and a 190 mm primary mirror. The secondary mirror is a separated piece of glass, or it is made coating the middle of the meniscus, depending on model.



This wide range of different schemes allows *Officina Stellare* to satisfy very different customers, for very different purposes, even non-astronomical, such as satellite tracking, laser communication, defense applications, and more.

We can customize telescopes for diameter, focal length, size of the focal plane, spectral response, and many other parameters, to fit any need, from the amateur astronomer to the aerospace & defense industry, to the space agencies.

That's why we offer so many different optical designs. We do not offer compromises to our customer. **We always offer the best solution. And if we don't have *your* solution on the shelf, probably we can design and build it!**

And why do our telescopes have focal planes that are much *bigger* than today's sensors? Because we want you to be happy about your instrument even 10-20 years from now, when you will use your *next* CCD camera, and the one after that...

\* Only the frontal lens (meniscus) of RH "Veloce" telescopes is made in Germany under *Officina Stellare* specifications.

## CHAPTER 2: WHAT IS IN THE BOX

Any *Officina Stellare* telescope comes, at the very minimum, with a set of Hex wrenches ("Allen" keys), documentation in electronic format on a USB key, and (excluding RH "Veloce") the electronic "box" and cables to control mirror heaters and tube fans; but many, many options are available, such as shutters, collimation tools, adapters for your specific optical train, environmental sensors, advanced electronics, and more. To help you check all the equipment, a checklist like this is provided.

* OFFICINASTELLARE	PL/CK LIST ELECTRONICS rev1	OC N.	Pag. 1
	S/N # 2015475204	Date: 03/15	

RC-600 USA

TC-01 (Telescope Controller 01)

- TC-01 unit
- DB-15 male/male flat cable
- DB-15 female/female flat cable
- 12Vdc power cable

ATC-02 (Advanced Telescope Controller 02)

ATC-02Ce (Compact external version)

- ATC-02Ce unit
- DB-15 male/male flat cable
- DB-15 female/female flat cable
- 12Vdc power cable with fuse
- RJ45 3 mt ethernet cable
- RJ45/DB-9 converter
- Environmental probe sensor

SH-2 (Shutter unit module - OPTIONAL)

- SH-2 unit
- DB-9/DB-9 connection cable ATC/SH2
- 4 motors with petals
- complete connection cables

ATC-02C (Compact internal version)

- 12Vdc power cable with fuse
- RJ45 3 mt ethernet cable
- RJ45/DB-9 converter
- Environmental probe sensor

SH-2 (Shutter unit module - OPTIONAL)

- 4 motors with petals
- complete connection cables

ATDe (ATC display/push button handpaddle - OPTIONAL)

- ATDe unit
- RJ45 3 mt ethernet cable

CD-Rom software and documentation

25/03/15 (Date and Signature) *W. F. ...*

* OFFICINASTELLARE	PL/CK LIST MECHANICS rev1	OC N.	Pag. 2
	S/N # 2015475204	Date: 03/15	

**mechanics:**

- collimation key
- collimation bar
- softcover
- shroud
- allen set keys

**electronics:**

- TC-01
- ATC-02
- SH-02
- SECMOT

**documentations:**

- CD-Rom
- Quality Control Certificate
- IT diagram

**adapters:**

- rear plate adapter
- adp for \_\_\_\_\_
- adp for \_\_\_\_\_
- adp for \_\_\_\_\_
- adp for \_\_\_\_\_

**Accessories:**

- focuser type: \_\_\_\_\_
- OS OAG
- OS collimation kit type: \_\_\_\_\_
- accessory \_\_\_\_\_
- accessory \_\_\_\_\_
- accessory \_\_\_\_\_

25/03/15 (Date and Signature) *W. F. ...*

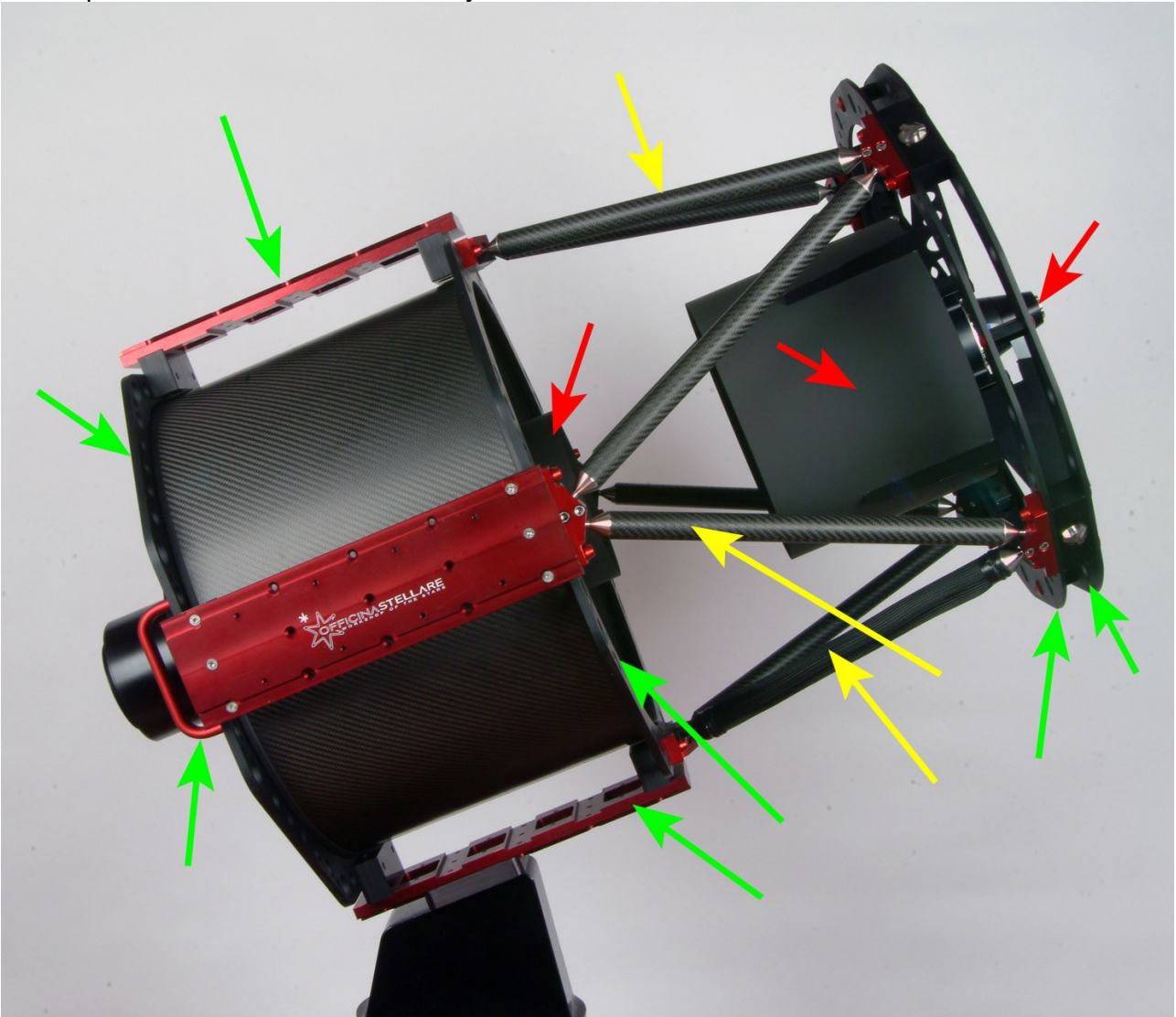
A two-page packing list for an *Officina Stellare* telescope. In this example, it is a RC-600 with ATC-02C controller (embedded on the scope), optional primary mirror shutter, optional hand paddle, but no adapters or accessories. Please read carefully your packing list, double check it against your order, and identify all the parts. Should you think something is missing, or you are not able to identify any piece, please contact *Officina Stellare* immediately. We will be glad to help you. Specific manuals may be provided for some specific accessories.



In big telescopes, the electronic panel is embedded on a side of the tube (left photo) or in the back of the primary mirror cell. In smaller instruments, the electronic may be a small, external box. But the internal circuit, the functionality and the use are identical.

### CHAPTER 3: HOW TO HANDLE THE TELESCOPE

Each *Officina Stellare* telescope has a very rigid and stiff structure, essential to maintain the optical parts in the correct reciprocal position during regular use. But some part of the telescope are quite delicate and precisely aligned. So pay great attention to "where you can grab" your telescope to move it and to install it on your mount.



In the above photograph GREEN arrows indicate the "strong" parts of the telescope. The metallic rings of the truss structure, dovetail plates and back handles. Any of this parts is ok to lift or handle the scope (use at least TWO of this parts). You can also use the carbon tubes of the truss structure, if needed (yellow arrows), if you use at the same time also one "strong" part. **Avoid** to lift the scope using the secondary mirror support, secondary mirror spider and all light baffles (red arrows). Those parts are quite delicate and very precisely aligned. Even if your telescope is small, we suggest to work with another person, to lift it on the mount.



If your telescope is heavy– and you need a crane or some other machinery to lift it – please use a strong rope and pass it into holes of the middle and rear rings of the truss structure, as you see in the photo at left. This procedure will preserve alignment and the telescope finish.



## CHAPTER 4: ELECTRONICS CONTROLS

Excluding RH telescopes, where there are only cooling fans, your Officina Stellare telescope is always provided with one of the following electronics packages:

- **TC01** – The basic model.
- **ATC-02** – The advanced model, that allows also to control all functions of your telescope from a remote PC.

Both require 12Vdc. The power consumption of the electronic itself (and fans) is minimal, but shutters and heaters may be a bit energy hungry, especially in big telescopes. Provide a 6A PSU (Power Supply Unit) for telescopes up to 400 mm, 10A for the bigger models.

**TC01** – (Telescope Control 01) –Controls only the primary and secondary mirror heaters and cooling fans. You see it in the following photo.



On the left side you see the connectors for 12V dc power and the on/off switch, if present. Units with no on/off switch are turned on and off simply plugging in the power cable.

Some units have an internal fuse (you must open the box to change it), while some other have the fuse on the power cable.

On the TC-01 you also see the connectors for the flat cables that power the primary and secondary mirror heaters. Cables have different connectors, so it is not possible to make wrong connections. The three knobs control the power to the heaters and the fans speed. As a general rule, do not use the heaters, unless you see some mist on the mirrors. If you turn on the heaters, try to keep them at the lowest temperature that avoid the mist. The intensity of the LED is proportional to the power of each heater. Regarding the fans, run them at maximum until the seeing stabilizes. After that point run them at half or one third power, or even turn them off until the end of the night. The use of cooling fans is proportional to the temperature change that the telescope suffers from day to night. The higher the temperature change, the longer you have to run fans to reach equilibrium.

**ATC-02** – (Advanced Telescope Controller 02) – The ATC02 is provided with a serial cable to connect is to a Windows computer, physically located in the vicinity of the telescope.

This PC, usually, will also manage a CCD camera, the mount, the dome, autoguide, and so on, and in case of a remote installation, it is remotely controlled via a dedicated software, like Remote Desktop, VNC or others.

On the ATC-02 you see the power connector, on/off switch and mirrors heaters connectors, that are identical to those of the TC-01, and works the same ways. The other connectors present are:



- **Environmental:** to connect a humidity / temperature sensor, embedded in the telescope body. Since those parameter are enough to compute the dew temperature, this sensor allows the telescope to keep its mirrors just "warm enough" to avoid condensation automatically, following the changes of the conditions during the night.
- **Hand:** connector for the optional hand pad (keyboard).

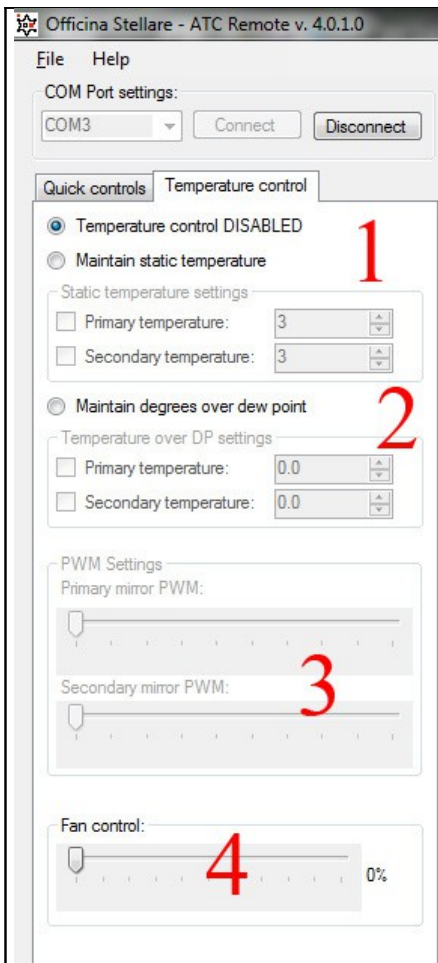
- **PC:** serial connection to the PC (cable provided). USB-to-serial converters works fine.
- **SH-1:** connection to the (optional) primary mirror shutters.

The ATC-02 also controls the optional electric motor that moves the secondary mirror (along its optical axis). The electrical connections for this motor, if installed, run on the same cable used by the secondary mirror heater. Move the secondary mirror will change the BFL (Back Focus Length, i.e. the distance between the back plate of the telescope and the focal plane). This system is used to focus the scope when a quick focus is essential, like is some non astronomical applications, or when the equipment at the prime focus is too heavy for a traditional focuser, or you need some extra BFL because of "thick" equipment at the focal plane, such as a filter wheel, a big CCD camera, off-axis guider, and so on. The telescope "knows" the best position for the secondary mirror – the design distance, where the optical performance are at best – and an internal sensor permits the mirror to find this optimal position. But the movable secondary mirror is the only choice in particular situations. You sacrifice a bit the optical performance simply to reach focus. The ATC-02 has been designed with the computer control in mind, for a wholly remote-controlled telescope. The hand pad is clearly a "second chance" solution. You can connect your ATC-02 to a PC *and* to a hand pad at the same time. The ATC-02 will accept commands from both sources. The latest command has priority.

#### 4.1) Use of the ATC-02 with the computer

To control the ATC-02 from the computer, you will use our **ATC-Remote** software, provided with your ATC-02. The software is quite simple, its interface is clearly divided in two. On the left you have two tabs ("Quick controls" and "Temperature control") where you can send commands to the telescope. On the right other two tabs ("General information" and "Data log") informs you about the current and "historical" status of your scope. Let's look each tab in detail.

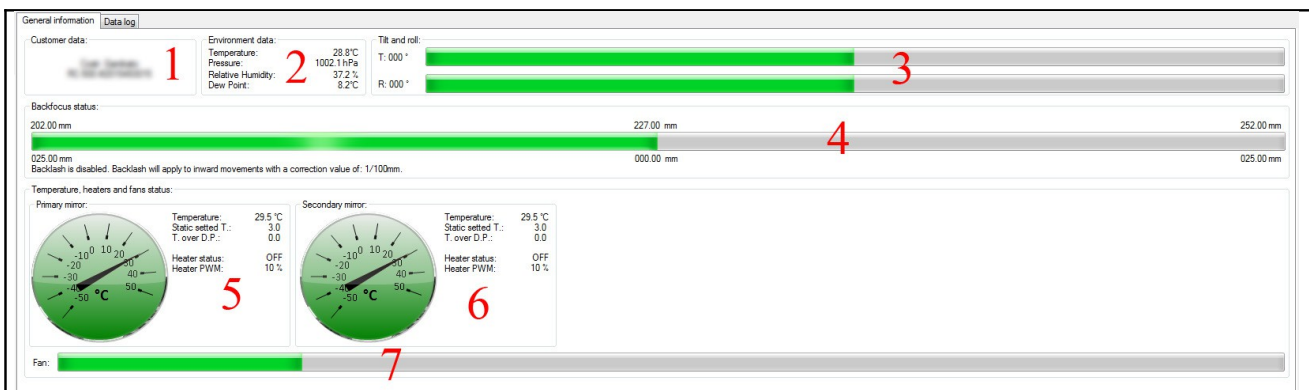
	<p style="text-align: center;"><b>"Quick controls" tab</b></p> <p>From this tab you can:</p> <ol style="list-style-type: none"> <li>1) Choose the serial port where your telescope is connected, and establish or terminate the connection. USB-to-serial converters can be used. In this case check with Windows the number of this "virtual" COM port.</li> <li>2) Open/close the shutters, if installed</li> <li>3) Enable the BFL control. The big "Find optimal position" button brings the mirror to the "optimal" position, set during manufacturing (best optical performance).</li> <li>4) Mirror movements. You can set an absolute position, or move the mirror by <math>\pm 1</math>, <math>\pm 0.25</math>, <math>\pm 0.05</math> or <math>\pm 0.01</math> mm per step</li> <li>5) You can enable a backlash compensation for the mirror movements. Backlash compensate the minimum "dead time" you see when you change the direction of motion in any mechanical system, like your secondary mirror. Use this parameter only if directed by <i>Officina Stellare</i> support. Usually you simply look at the image captured by the scope to change secondary mirror position, but for particular situations a backlash control is useful.</li> <li>6) With this buttons you can turn on/off the hand pad, if installed. This is to avoid the local control of the telescope (if you are using it remotely) or simply to reduce the illumination inside the dome.</li> </ol>
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## "Temperature control" tab

From this tab you can:

- 1) Leave the temperature control OFF, or keep the mirrors at a constant temperature (only ABOVE ambient, of course).
- 2) Keep the mirrors a given temperature above the dew point temperature (calculated by the internal sensor).
- 3) Set the Pulse Width Modulation of each heater. PWM is something like a limit to the "maximum power available". If you heat the mirror too quickly, the mirror may warp a bit, (temporarily!) and produce bad images. To warm the mirror slowly, set the PWM to no more than 50%. The software will warn you if are using a "high power" set.
- 4) Set the fans speed. Run them at maximum until the seeing stabilizes. After that point run them at half or one third power, or even turn them off until the end of the night. The use of cooling fans is proportional to the temperature change that the telescope suffers from day to night. The higher the temperature change, the longer you have to run fans to reach equilibrium.



## "General information" tab

From this tab you read:

- 1) Owner data, as written in the memory of the scope when it was produced.
- 2) Environmental data (temperature, pressure, relative humidity and dew point), measured (or calculated) by the telescope sensors.
- 3) Tilt and roll of the scope, as read by gravity-referred sensors internal to the scope. This data is useful to control if the telescope has reached the "park" position or is moving at all. In other word, this is a way to control if the telescope mount is working properly. This sensors are not sensitive enough to *point* the telescope, but will be useful during the setup and use of a remote controlled telescope. By the way, we suggest to install webcam, possibly with IR capabilities, in the dome, to take a look to your telescope during operation!

- 4) Back focus position. This data is meaningful only if the secondary mirror motor is installed. The minimum, optimal and maximum position are real measurements, in mm.
- 5) Real temperature, set temperature and heater status for the primary mirror
- 6) As above, for the secondary mirror
- 7) Fan speed. Parameter 5, 6 and 7 are set in the "Temperature control" tab.



### "Data Log" tab

Simply shows as two multiple Y-scale graphs a log of all the above parameters. On the bottom you read the COM port, telescope model, software version, telescope firmware version.

## 4.2) Use of the ATC-02 with the hand pad

The hand pad is connected to the ATC-02 via a male-male RJ-45 cable. The cable fits also the "PC" port on the ATC-02, but there is no risk of damage if you make a mistake. If you plug the hand pad cable in the "PC" connector or vice-versa, the hand pad (or the PC connection) will simply not work. Use the correct connector!

As soon as you power up the ATC-02, the hand pad will briefly show the firmware revision. This information will be useful if you contact *Officina Stellare* customer service. After the firmware revision, you will see briefly the serial number, telescope model and owner information, written in the memory of the scope following your order. Finally, the hand pad will start to "cycle" between five different screens.

The first three lines of the display will continue to cycle between the five "screens". The user will interact only with the last line.

This table summarizes what you read in the five "screens". Look at the hand pad for a while to familiarize yourself with this five "screens"

	You read...	Notes
<b>First screen</b>		
1 <sup>st</sup> row:	Date and time	Format is dd/mm/yy, 24h. Available only if a computer is connected, and read from the computer. There is no clock or battery inside then ATC-02.
2 <sup>nd</sup> row:	Shutter status and fans speed	If shutters are not installed, their status is always "OPEN". Fan speed is given as percent of maximum.
3 <sup>rd</sup> row:	BFL position and last command	The BFL (Back Focus Length) is the distance between the focal plane and the back plate of the scope. "Local" or "Remote" indicate if the last command to the position of the secondary mirror has been given locally (via hand pad) or from the PC. This information is meaningful only if the optional secondary mirror motor is installed.
<b>Second screen</b>		
1 <sup>st</sup> row:	"Mirrors temperatures"	Just a reminder of what you read in this screen – obviously the temperature of the two mirrors.
2 <sup>nd</sup> row:	P xx.x OFF S xx.x ON	Primary and secondary mirror temperatures, in Celsius degrees, and if each heater is ON or OFF at the moment.
3 <sup>rd</sup> row:	Set x.x Set x.x	Set temperature for the two mirrors
<b>Third screen</b>		
1 <sup>st</sup> row:	Hum xx.x, Temp x.x °C	Humidity in % and local temperature
2 <sup>nd</sup> row:	Pressure xxxx mB	Local pressure, in mbar
3 <sup>rd</sup> row:	Dew point xxx °C	Local dew point, in °C. Dew point is calculated from temperature and relative humidity.
<b>Fourth screen</b>		
1 <sup>st</sup> row:	"Auto Heating"	Just a reminder of what you read in this screen – the status of the mirror heaters.
2 <sup>nd</sup> row:	Prim... OverDwP...	If the primary mirror heater is ON or OFF, and the required temperature over dew point (usually a good choice is 2°C above dew point).
3 <sup>rd</sup> row:	Sec... OverDwP...	Same as above, for the secondary mirror.
<b>Fifth screen</b>		
1 <sup>st</sup> row:	Backlash: ...	Backlash: see point 5) of the "Quick controls" tab, above, for a description of this function.
2 <sup>nd</sup> row:	Direction: ....	Direction of backlash (inward or outward)
3 <sup>rd</sup> row:	Value...	Backlash value, in units of 1/100 mm



To give commands to the telescope via the hand pad, you will use the four buttons, marked [E] (Enter), [S] (Step), [+] and [-].

- [+] and [-] change the current menu item or value (once you entered one specific function).
- [E] enters each function from the menu and goes back to the menu after you set the value.

- [S] is used only to change the Step of the secondary mirror movement, to change the BFL.

The menus available (use [+] and [-] to see them in the last line of the display) are described here: press [E] to enter each function

#### SET TEMPERATURE

Use [+] and [-] to change the values, [E] goes back

#### SET FAN SPEED

Use [+] and [-] to change the values, [E] goes back

BFL CONTROL. This is the only menu item that has sub-menus. Again, use [+] and [-] to choose, [E] to enter each function

#### MOVE SECONDARY MIRROR

Use [+] and [-] to move the mirror, [S] to change step, [E] goes back

#### FIND OPTIMAL

Pressing [E], the mirror will reach the optimal position, set during manufacturing.

#### BACKSLASH ENABLE

Press [+] to enable the backlash compensation, [-] to disable, [E] goes back

#### BACKSLASH VALUE

Use [+] and [-] to change the backlash value (unit is 1/100 mm). [E] goes back

#### BACKSLASH DIRECTION

Use [+] and [-] to set the direction of the backlash movement. [E] goes back

#### EXIT AND GO BACK

With [E] you go back to the top level menu.

#### DISPLAY BACKLIGHT

Use [+] and [-] to change display brightness, [E] goes back

#### SHUTTER

Use [+] and [-] to open or close the shutter, [E] goes back

## CHAPTER 5: COLLIMATION

The purpose of collimation is to bring the optical axes of all optical elements to coincide – and bring them as close as possible to the *mechanical* axis.

Collimation is important for any optical system, but it is really *essential* for a telescope. The best telescope of the world will produce horrible and useless images if it is not collimated.

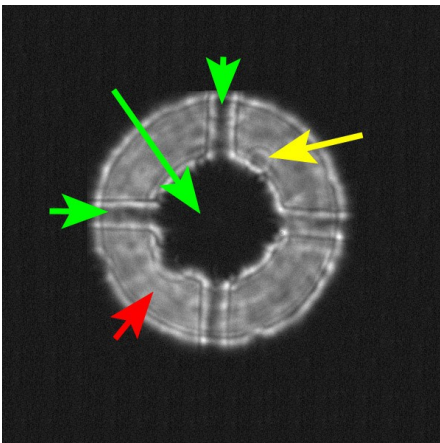
As a general rule, the faster (i.e. with a *low f/ratio*) the telescope, more critical is the collimation.

**This procedure is similar, but not identical, to the procedure for the “Veloce” series of astrographs . For the “Veloce” collimation please read also Chapter 7.**

Every telescope is shipped from our plant perfectly collimated. We use several dedicated tools and some time to achieve this. But vibrations or little shocks during transport may move a bit some parts. A movement of any optical element of less than a quarter of a millimeter (less than 1/100 if an inch) will require the scope to be collimated. Sorry, nobody's fault – it's the laws of optics. The good news is that since every *Officina Stellare* telescope has a very good mechanics, once you have a good collimation, the telescope will stay collimated for a long time.

### 5.1) Some notes about collimation

The first, obvious, step in collimation is to check if your telescope needs collimation at all. All you need is a bright star, high in the sky (45° or more above horizon) and some eyepieces, or a camera that shows images quickly (we suggest at least one image per second; a webcam or a DSLR with LiveView is a perfect choice). Leave your telescope reach the ambient temperature before to proceed with collimation, say 90 minutes after sunset. The cooling fans will help a lot. You can also use an artificial star, available by astronomical equipment retailers, but a real star is much better. Start looking at the star with the lowest power (i.e. longest focal length) eyepiece you have. DO NOT USE 90° PRISMS.

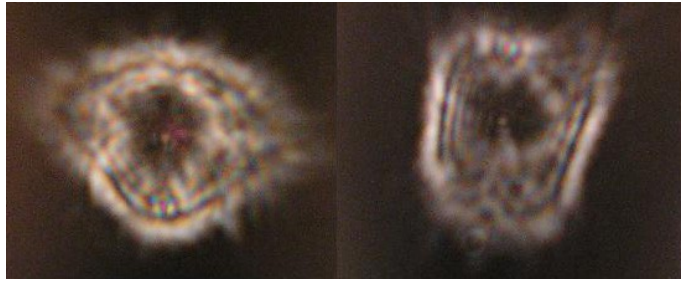


If the secondary mirror has an electric motor to change the BFL (Back Focus Length), **turn “ON” the scope electronic control and set it to the “factory zero”**. The command is "FIND OPTIMAL BFL". Turn off the scope when done. This will set the mirror spacing for best performance, as established by the optical design.

Point the star, bring it in the very center of the field of view and bring it out-of focus. It is not important if you go in-focus or out-focus. You should see something like the image at left:

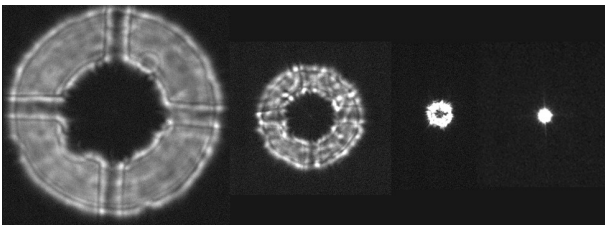
- The white disk is the out-of focus image of the star.
- The "shadow" of the secondary mirror and its supports are clearly visible (green arrows). Here also a cable protruding from the secondary mirror assembly is visible (the “bump” in the direction of the red arrow).
- All the white area (red arrow) will change continuously, because of the turbulence in the Earth's atmosphere (in astronomy the stability of the atmosphere is called the "seeing").
- A grain of dust somewhere on the optic may show a circular pattern (yellow arrow). Just ignore it, this has no effect on collimation, and has no effect on telescope's performance.

If the seeing is really terrible – i.e. there is a strong turbulence in the atmosphere – the out-of-focus star may change "wildly", and change in a fraction of a second in size, color, shape (image at right). If this is the case, the seeing is simply too bad to continue. You have to wait another night (or use an artificial star). If this happens when you have just open your "warm" dome in a very cold night, just wait one hour to check if the problem is due to local turbulence (the telescope is much warmer than the air). It is a good practice to open the dome (and start telescope's fans) as soon as the sun sets. By astronomical twilight, the telescope will be very close to thermal equilibrium with the environment, minimizing the thermal (local) turbulence.



## 5.2) How to *check* collimation

1. Be sure your telescope is in thermal equilibrium with the environment.
2. Start with the lowest power (longest focal length) eyepiece available. DO NOT use a 90° prism.
3. Choose a bright star at least 45° above horizon. Bring the star in the center of the field of view and look at the defocused image. You MUST use a star, a planet cannot be used since it is not a point-like source of light.
4. If the dark shadow is clearly NOT in the center of the white disk jump to section 5.3, "Collimation procedure".
5. If the dark shadow of the secondary mirror looks in the middle of the white circle, change a bit the focus, using the telescope focuser, NOT the electric motor of the secondary mirror, if present. The white disk will become smaller or bigger. Check if the shadow is always in the middle (the human eye is a very good "device" to control if two circles are concentric). Always keep the image in the center of the field of view using the telescope mount. Focus from a "very big" to a "very small" image, and continue to check if the shadow is always in the middle of the white spot. Find the size of the spot that is more comfortable for your eye to detect concentricity. If you are using a camera you may have to change exposure time; you may also measure the single images using specific software (or a simple ruler, working directly on the computer screen). If you are using a camera set the exposure time so you can see different shades of gray in the star image.
6. If the image is too bright or too dim to see clearly the shadow of the secondary mirror, choose a different (dimmer or brighter) star, or change exposure time.
7. If the shadow always look concentric, change eyepiece with a more powerful one (shorter focal length) or zoom the electronic image, and repeat steps 3-5. For this step a visual magnification of around 200-300x is a good choice.
8. If the shadows always look concentric, the collimation of your scope is "good enough" for any reasonable application. Jump to sections 6.5 and 6.6, for "fine tuning".



The image at left gives you an idea about what you will see during this procedure while you change focus.

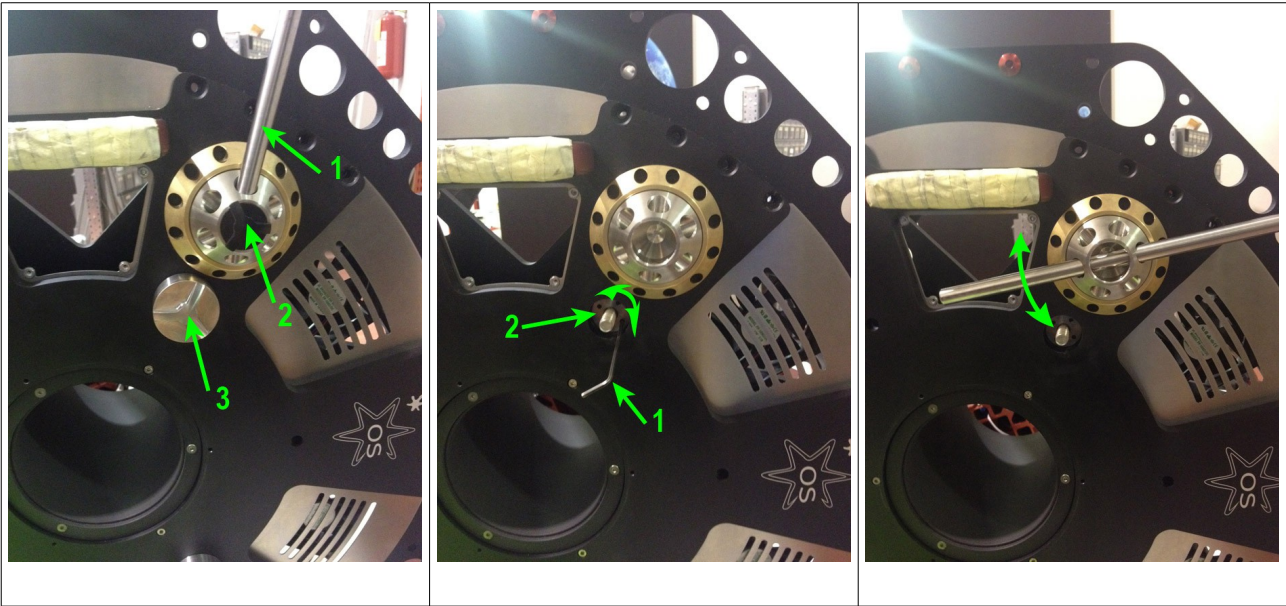
Remember, always keep the star in the center of your field of view, using the telescope mount.

## 5.3) Collimation procedure

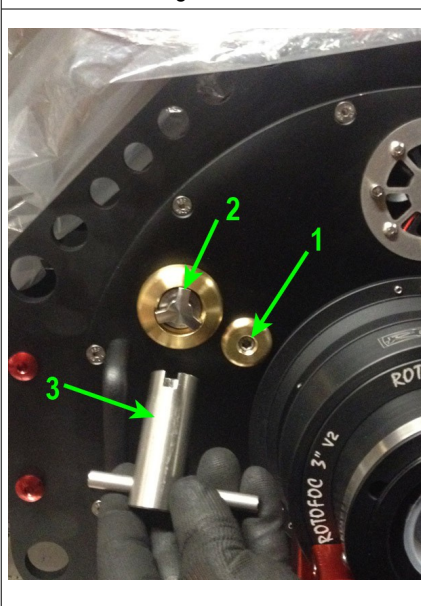
If the shadow *is not* in the middle of the white disk, start collimation from the primary mirror, for the very simple reason that 90% of the times you can reach a good collimation working only on the primary mirror, and you need no particular tool to do so.



First of all, you must learn how to move (tip-tilt) the primary mirror. Take a look to the images in this page and familiarize yourself with the tip-tilt screws of your primary mirror.



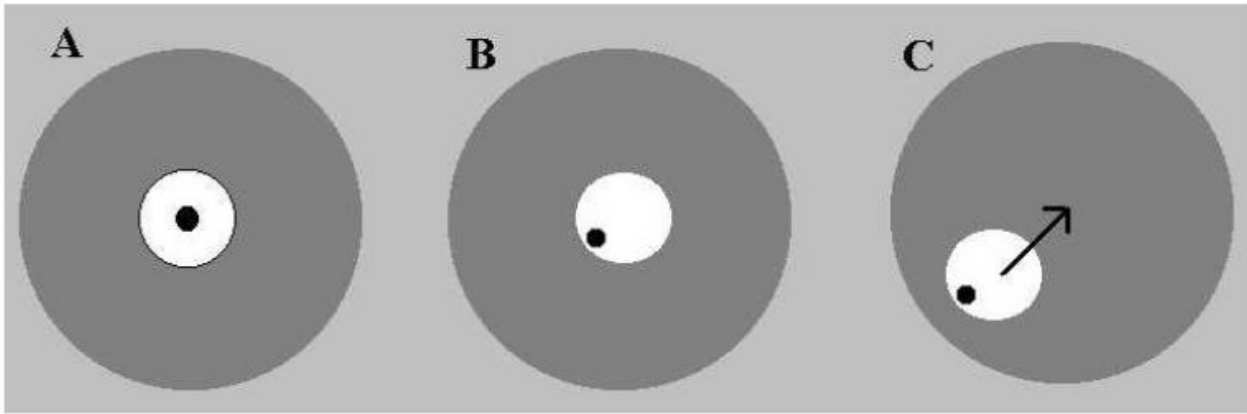
In "big" scopes (i.e. 50 cm and above) you must follow this procedure to operate on the three big screws that control the tip-tilt movements of the primary mirror. This screws are rotated using a metal bar or a big screwdriver (1, left image). But before you can operate them, you have to remove the black cap (2, left image) and remove the external locking "bolt" (3, left image). The tool to do so has been provided with the scope. Once you have removed the external locking bolt, you will see the *internal* locking bolt (2, center image). Use a small hex wrench to move it a bit *inside* the scope (1, center image). Just rotate it 4-5 turns. The bolt must move *away* from the back plate, i.e. go *inside* the telescope. The big tip-tilt screw can now be operated using a metal bar or a big screwdriver (right image). Please note that even in big scopes each screw turn will move the mirror just one millimeter. Collimation screws are spring loaded (using cup springs in big scopes) so there is no need, when you tight one screw, to loose the other two or vice versa. **When you have set the tip-tilt position of the primary mirror, bring the internal locking bolt again in contact with the back plate of the scope** and put back in position the external locking bolt and the black cap. There is no need to apply too much force on the internal locking bolt. Just rotate it until it stops against the back plate of the telescope. It is the external bolt that does the real job.



In smaller telescopes there are three big screws to set the tip-tilt position of the primary mirror (number 2 in the photo at left). If your telescope has also the safety set screws (1) loose them 4-5 turns before to operate on the big screws using the specific tool (3), included with the scope. When you finish, tight the safety set screws. Do not apply too much force. Just let them touch "gently" the internal mirror cell.

Please note that in all Officina Stellare telescopes each collimation screw turn will move the mirror just one millimeter. Collimation screws are spring loaded, so there is no need, when you tight one screw, to loose the other two or vice versa.

Now go back to our defocused star, where the shadow is not in the middle of the white circle and... go to the next page!



1. The gray circle is your field of view through the eyepiece. The white circle is the defocused star and the black spot is the position of the secondary mirror's shadow. A collimated scope will look like "A", above, at any magnification.
2. If the shadow is not in the middle (in our example, "B", is at the "8 o'clock" position) then move the telescope, using the mount motors, so the image goes in the same direction, so the defocused star goes near the edge of the field of view at the "8 o'clock" position, like in "C".
3. Try to tight or loose a bit one of the collimation screws. Discover which screw (or screws) move the star image in the direction of the center of the field of view (like the black arrow in "C"). When the image will go back to the middle of the field of view, it will be more centered.
4. Repeat step 2-3 until you reach collimation (image "A", above).
5. Use a higher magnification and repeat.

Some notes about this operation:

- It is very unlikely you have to move any collimation screw more than one turn – probably you will reach collimation with less than half a turn.
- Have someone to help you while you look at the eyepiece – or use a camera so you can see the image while you work on the screws. It is a good idea to label the three collimation "A", "B", and "C", and memorize the direction of the movement given by each screw. Obviously the star will move in the opposite direction along a line when you turn screw "A" clockwise or counterclockwise. Movements due to screws "B" and "C" will be 120° apart.
- It is a good idea to mark the initial positions of collimation screws with a felt tip pen and keep track of what you do (like "screw A 45° CW – screw B CCW 30°..." and so on). Doing so, you will always be able to "undo" a wrong action, and, if needed, to go back to the original position.
- In all *Officina Stellare* telescopes the collimation screws are spring-loaded, so if you tight one screw there is no need to loose the other two.
- And, very important: KEEP YOUR TIME, AND START WITH SMALL MOVEMENTS (1/8 or 1/16 of a turn).

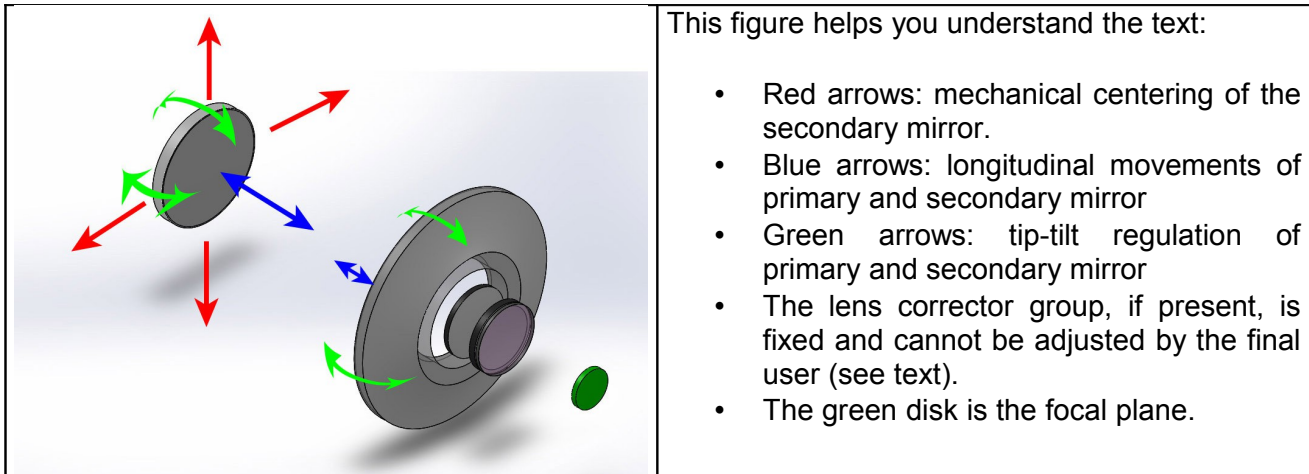
When you have a perfectly symmetrical figure at any magnification (i.e. when the dark shadow is always in the middle of the de-focused star) you are done, and you can use your scope for any reasonable purpose. Go to section 6.5 and 6.6 for fine collimation and focuser tip-tilt.

#### 5.4) And if I'm not able to reach collimation?

It is quite unlikely, but it is possible that your secondary mirror moved a bit during transport. If this is the case, you will not be able reach a good collimation using only the primary mirror tip-tilt control. You have to refer to Chapter 6, Collimation "from scratch".

## CHAPTER 6: COLLIMATION “FROM SCRATCH”

The following procedure should be used only if you are not able to reach an acceptable collimation using the procedure described in Chapter 5. We suggest to contact our customer care ([support@officinastellare.com](mailto:support@officinastellare.com)) before to try the following procedure; just to check with our technicians that the telescope really needs collimation, or that the problem is not elsewhere in the optical train. **This procedure DOES NOT APPLY to the RH “Veloce” family of astrographs.**



During this “collimation from scratch” procedure you will work on *all* the degrees of freedom visible in the above figure. The final user *cannot* work on the lens corrector group, but since those elements are “glued” in position and they have very strong metal cells and spacers, it is in practice impossible they move or get loose. In other words, you will set the mirrors longitudinal position (blue arrows) and orientation (green arrows) **relative to the fixed lens group, if present** or relative to the back plate, in RCs. Also the concentricity of the lens group (and/or back plate) with the primary mirror is guaranteed by the sturdy primary mirror cell and back plate structure, and cannot be changed. It is fixed by construction.

**VERY IMPORTANT! There is not an “unique” solution for collimation.** There are “families” of positions (for the optical elements) that do provide an image quality within the telescope specifications. In other words, if the secondary mirror is a bit off from its “perfect” position, the collimation process will bring also the primary mirror a bit “off”, but in a way that compensate for the secondary mirror “error” (within thigh limits, of course). For this reason it is absolutely normal that, after collimation, the optical axis of the telescope does not coincide with the mechanical axis of the tube, even if the telescope does perform perfectly form the optical point of view and the mount is “perfect”. This difference, if measurable, is usually really small (a few arcmins maximum) and can be compensated by the pointing system of the mount creating a “mount model”.

**The Takahashi collimation tool (or at least a collimation eyepiece) is required for this procedure. An holographic laser (included in the Officina Stellare deluxe collimation kit) may be useful if your mirrors are “wildly” out of position (typically if you have disassembled you telescope, like for mirror re-coating).**

You will need also a Vernier caliper. If it is digital (usually 0.01 mm resolution) it is better, but also the traditional mechanical version (usually with a resolution of 0.05 mm) is ok.

If you will use the laser, you will also need to point the scope perpendicular to a wall, to project on the wall the laser pattern. If a wall is not “available”, a big piece of cardboard or a wood plate

will do the job. What is important is that this flat surface can be set *perpendicular* to the optical axis, with a reasonable tolerance. Just check with a meter tape that different points of the frontal ring of the telescope have the same distance from the flat surface, within a centimeter or so. This is enough.

Collimation from scratch (or CFS, for short) is a 5 steps procedure:

1. Mechanical centering of the secondary mirror (Section 6.1).
2. Check the distance between mirrors (Section 6.2)
3. Secondary mirror tip-tilt regulation (Section 6.3).
4. Primary mirror tip-tilt regulation (Section 6.4 and 6.5)
5. Focuser (or camera) tip-tilt, if needed (Section 6.6).

Steps 1 and 2 are usually only just quick checks. It is very unlikely you will need to do any change during those steps. Also step 5 usually requires no action from the user (it is more probable you need to do something in RiFAST and RiLA telescopes, because of the lower f/ratio). The “core” of the collimation process is only steps 3 & 4.

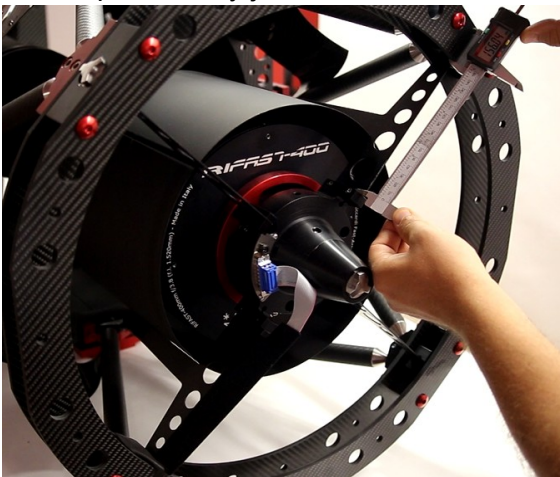
Steps 1 and 3 can be performed indoor. All other steps requires at least an artificial star, or (much better!) a real star during night. The whole process will require two to three hours. The good news is that after this procedure you will not touch the telescope collimation again for a long time – even years, if you do not transport the telescope frequently. After a “normal” shipment, usually you have to perform only step 4, as described in Chapter 5.

We strongly suggest to have someone who can help you, at least for step 3, otherwise you will have to move many times from the back of the telescope to the front, where the collimation screws of the secondary mirror are located.

Let's see each step in detail.

### 6.1) Mechanical centering of the secondary mirror.

This step is usually just a check. Each telescope is accurately set during manufacturing! Using the



vernier caliper, check the secondary mirror support is *mechanically centered* in the front ring of the telescope; i.e. all four “spokes” must have the same length, within half a millimeter (0.02”). If it is not, adjust the screws you have at the end of each "spoke" of the secondary mirror spider. Tightening a screw, you move the mirror assembly *toward* that screw. Before to tight a screw loose the opposite screw of the same amount to permit the movement. Each turn of those screws produces 1 mm shift of the secondary mirror assembly.

## 6.2) Check the distance between mirrors

Two important definitions needed to understand this section.

- The **BFL** is the *back focus length*, i.e. the distance between the flat back plate of the scope and the focal plane, when the telescope is focused at infinite.
- **M1M2** is the distance between mirrors (surface to surface). M1M2 is a short form for “distance between Mirror 1 – the primary - and Mirror 2 – the secondary”.

Any telescope has his design M1M2 and BFL. When shipped from our plant, M1M2 is correct within a fraction of a millimeter, and the BFL is correct within 1 mm. When you change M1M2, you also change the BFL (if the secondary mirror is a bit more *closer* to the primary than it should be, the BFL will be significantly *longer*). Just as an idea, if you change M1M2 by 1 mm, the BFL will change by 4-9 mm, depending on optical scheme.

When you ordered your telescope, Officina Stellare has (usually) provided the whole *optical train*, i.e. all the mechanical parts needed to keep, at the same time:

- The telescope focused at infinite.
- The camera sensor (or eyepiece focal plane) at the design BFL.
- M1M2 at the design value.

The focuser, in theory, is used only to compensate for dimension changes due to temperature, different filters thickness, eyepiece model when working visually, and some other minor factors. Optical performances are guaranteed **only for minimal changes of M1M2**. If you have an electric motor fit on your secondary mirror, the movement permitted by the software is always very small – a few millimeters at most. This does guarantee that your scope can always perform within specifications. **If you change M1M2 outside the design range, severe degradation of optical performance may occur.**

Let's see how to check and change, if needed, M1M2.

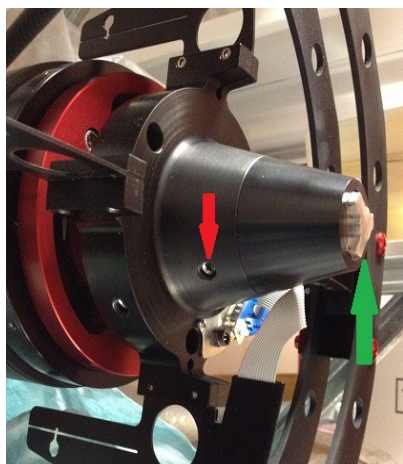
- For this step **you need to focus on a real star**, using a camera (or an eyepiece) where is *clearly marked* the position of the focal plane. Reflex cameras (both traditional or digital) are perfect for this job. A standard symbol on the camera body always tells you where the focal plane of the camera is. Look the photo at right: the symbol looks like the planet Saturn with edge-on rings. The straight line marks the exact position of the sensor (or film, i.e. the focal plane). **When the star is focused, this is also the position of the focal plane of the telescope.** Bring the star to a sharp focus (your eye judgment is good enough). Use the focuser, not the secondary mirror movement, to change focus. If you don't have a standard focuser (you only have the BFL control on the secondary mirror) see the note at the end of this procedure.
- Measure the distance between the backplate of the telescope and the focal plane (symbol on your camera) using a tape meter. If it is within 4 mm of the declared BFL (*Back focus length*) of your scope, interrupt this procedure and jump to step 6.3, secondary mirror tip-tilt.
- If you need to correct the BFL, there are different procedures for different telescope configurations: follow the appropriate procedure for your configuration:



**CASE A: you have both the BFL electric motor on the secondary mirror AND a regular focuser:** use the focuser to move the mark on the camera body to the correct distance from the back plate of the telescope. The star will look a bit out-of-focus. Use the BFL motor to

reach a good focus and stop the motor. This position will be your new “zero”. During regular use, reach perfect focus with the focuser.

**CASE B: you only have the “regular” focuser and no BFL motor.** Same as case A, but you correct the longitudinal position of the secondary mirror manually. See photo at left. Bring the focal plane indicator (on your camera body) to the design BFL and then focus your real star moving the secondary mirror. You shouldn't move it more than 1 mm (one turn of the screw).



How to move the secondary mirror manually. Loose the safety screw (red arrow) and rotate the big frontal screw (green arrow) using the same tool provided for the primary mirror screws. One turn of this screw does the mirror 1 mm. When done, tight again (gently!) the safety screw.

**If you don't have a “regular” focuser** (an unusual solution needed for some telescope / camera combination) obviously you have always to use the BFL motor, because as a matter of fact you always change focus changing M1M2.

**IN ANY CASE, A, B or C,** if you need to move your secondary mirror more than 1 mm, to reach focus when the camera is at the nominal BFL, then your primary mirror is probably in the wrong (longitudinal) position, i.e. it is too close or too far from the secondary. It is quite unusually that this may happen, but it is not impossible. If this is your situation, here is the procedure to solve the problem:

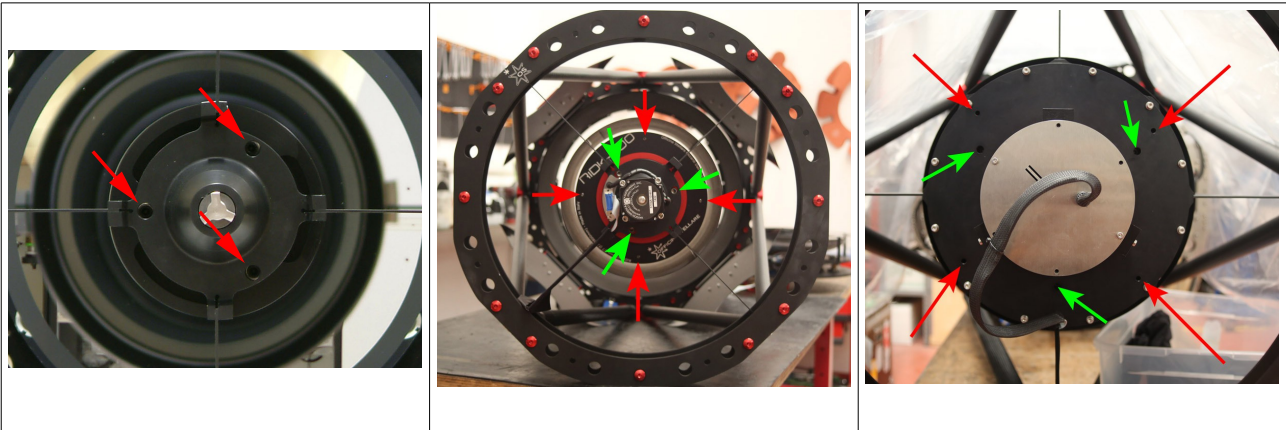
1. Set the secondary mirror position to factory zero, if you have the BFL motor.
2. Focus your camera on a real star and measure the BFL.
3. If the focus is too far *inside* the scope (i.e. you measure a back focus length *shorter* than nominal) you need to move the primary mirror *toward* the secondary mirror. Loose safety screws, if present, and rotate the three collimation screws of the primary mirror counterclockwise, all by the same amount. As a matter of fact, you are changing focus moving the primary mirror. Remember that each complete turn of the screws will move the mirror 1 mm, and this will move the focal plane by 4 to 9 mm, depending on optical scheme. So, if your focal plane is too "short" by 8 mm, you will have to move the primary mirror by 1-2 full turns of the screws. Try ½ turn first, then another ¼ turn, and so on. **What is important is that you move each screw by the same amount (and of course in the same direction!).** After each movement, refocus the star (using the focuser, not the secondary mirror movement) and return to point 2.
4. If the focus is too far *away* from the scope (measured back focus *longer* than nominal) follow the procedure described at point 3, only changing the action on the primary mirror screws (you *tight* them i.e. turn them *clockwise*, to pull the mirror toward the backplate).
5. Just a note: when you will “fine tune” the tip-tilt position of the primary mirror (sections 6.4 and 6.5) you will not change its longitudinal position significantly.



### 6.3) Secondary mirror tip-tilt regulation.

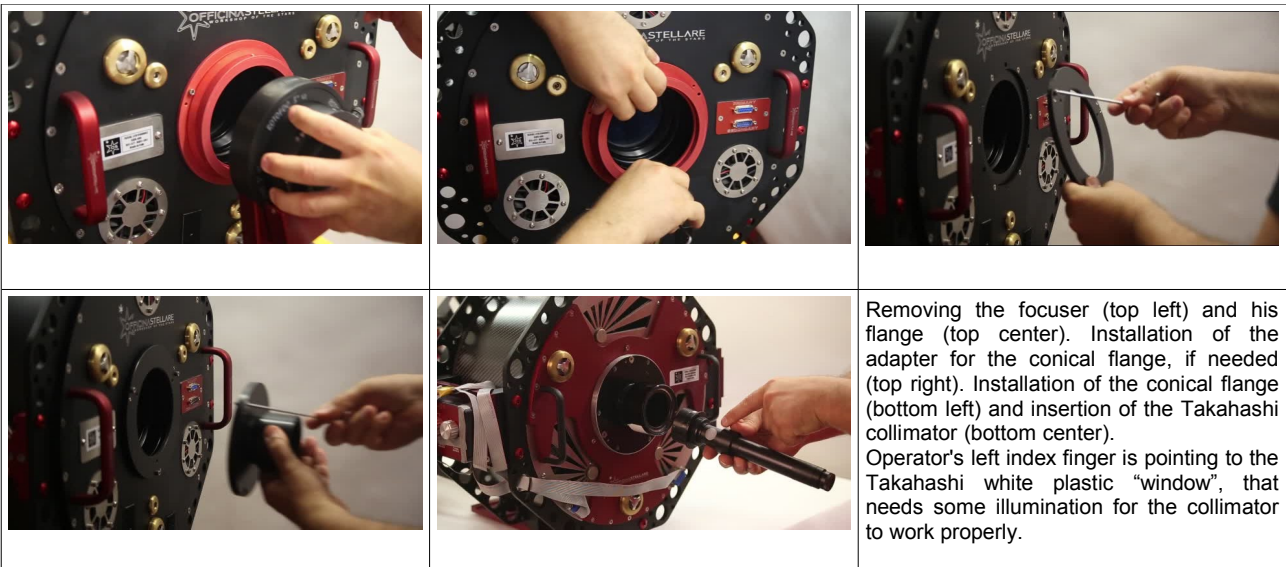
1. Identify the collimation screws of the secondary mirror (3 screws 120° apart, visible looking the telescope from "the sky"). See photos next page.
2. **IMPORTANT:** if the secondary mirror has an electric motor to change the BFL (Back Focus Length), **turn on the scope electronic control and set it to the "factory zero".** The

command is "FIND OPTIMAL BFL". Turn off the scope when done. This will set the mirror spacing for best performance, as established by the optical design.



Different secondary mirrors as seen from "the sky". In any design **the collimation screws are always three, set 120° apart, and bigger than others (tension screws, carter screws...)**. Touch nothing but the collimation screws, unless otherwise directed by Officina Stellare technical service. In the simplest design (at left) there are only the collimation screws (the big central one is to disassemble the mirror or move it longitudinally). In different designs, where a secondary mirror motor is installed, the motor can be visible (center) or hidden (right). Collimation screws are always bigger and 120° apart (green arrows in the center and right photos). In the center and right photo, the red arrows point to the four "tension" screws, locate 90° apart from each other. Please be sure to identify and use the 3 collimation screws. Again, collimation screws are always bigger than other screws.

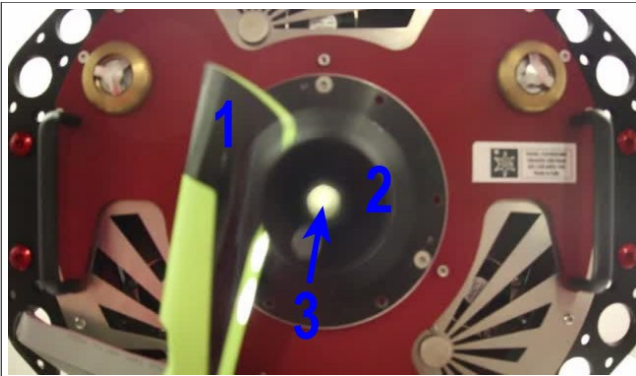
3. You will now use the Takahashi collimator. If you use the collimation eyepiece instead, read the note at the end of this section. To use the Takahashi, remove the telescope focuser and its flange, if present, and install the conical flange, provided with the collimation kit. If the telescope design requires an adapter between the back plate and the conical flange, this adapter is provided. See photos below.



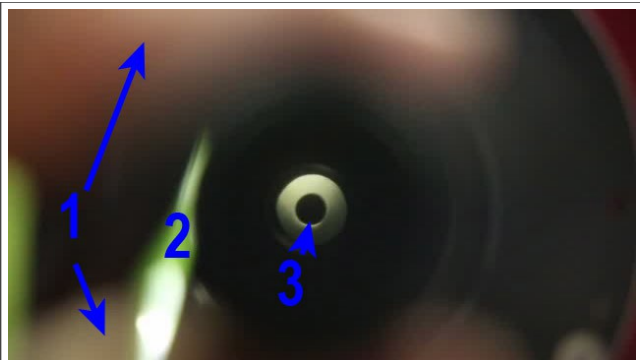
Removing the focuser (top left) and his flange (top center). Installation of the adapter for the conical flange, if needed (top right). Installation of the conical flange (bottom left) and insertion of the Takahashi collimator (bottom center). Operator's left index finger is pointing to the Takahashi white plastic "window", that needs some illumination for the collimator to work properly.

4. Insert the Takahashi collimator ("Tak", for short) in the conical flange and lock it in place. Point the telescope to a well illuminated wall or to the daytime sky (NOT toward the Sun!). If you work indoors, you may need to illuminate the white plastic "window" located on the side of the Tak. A flashlight will do the job. If outdoor, ambient illumination should be enough to use the Tak, if you point the plastic white window "up" (see also the following images).
5. Take a look to the photos in the next page. Sliding the focus of the TC from "full inside" position out you will see at the beginning only an indistinct circle of light, then the sharp black circular spot (embedded in the TC optics) *and moving the focus further* one or more of the concentric circles painted on the secondary mirror.

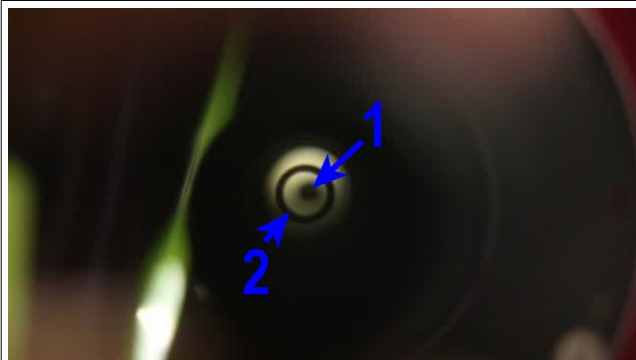
6. On many scopes it is not possible to have the spot *and* the circles in focus at the same time, but it is easy to see if the spot is concentric to the circles.
7. Using the collimation screws of the secondary mirror center the black spot with the circles. It is much easier if you have someone who can assist you. **Take your time, and try to be as precise as you can.**



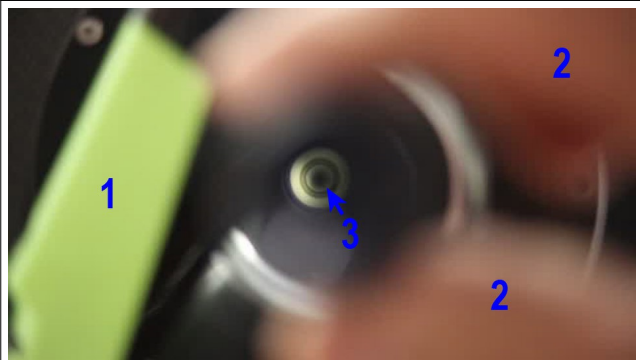
The telescope from behind with the Tak inserted in the conical flange, completely "inside". You see the flashlight we used to illuminate the white plastic window (1), the TC itself (2) and only a out-of-focus spot of light (3)



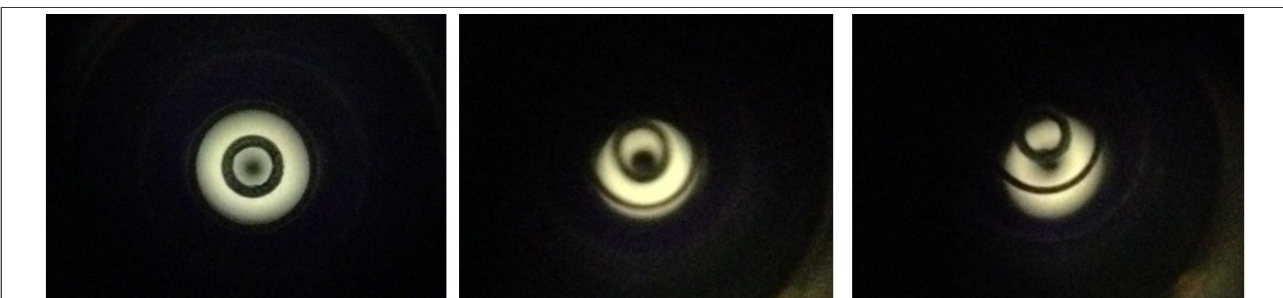
Here you see the users' fingers (1) pulling out the collimation tool. You see also the flashlight (2). After 1-3 centimeters of movement, you will see the black dot, that is **embedded** in the Tak (3).



Extracting the Tak another centimeter or so, the black dot will go out of focus (1), while the ring printed on the secondary mirror will come into focus (2). In this image it is clear the black dot and the ring are not concentric. Please note that **this image (spot and circles) does not change** even if you "shake" the Tak. Try that!



This image was taken after the tip-tilt regulation of the secondary mirror. You see the flashlight (1), the users' fingers (2) and the black dot and the circle on the mirror, now concentric.



Just to give you an idea, a single collimation screw was rotated about 45° (i.e. just 1/8 of a turn!) to change the image from "perfect" (left) to "horrible" (right). Please note that you **MUST** reach "perfection". The image in the middle is **NOT ACCEPTABLE** even if the black dot is within the innermost circle. It must be as concentric as possible. Note that in the "perfect" image only the innermost circle painted on the secondary mirror is visible, while in the other two also part of the second circle is illuminated. Usually you need to work on more than one collimation screw to reach "perfection". The TC is very sensitive, and clearly shows a tilt of the secondary mirror smaller than one arcmin from the correct position.



After this step your secondary mirror is in its correct and “final” position, and you will not touch it again for the rest of the collimation procedure.

Please note that *theoretically* it is possible to use the TC to collimate also the primary mirror (there are a lot of procedures on the web... and some of them are WRONG!), but this would require to remove one or all baffles, a task that is a bit “dangerous” (baffles are very delicate and you would work very close to the primary mirror) and in some telescopes this does also require to remove at least one bar of the truss structure.

For this reason, we will suggest a bit slower but much “safer” procedure, that simply requires to look to a star (real or artificial). If possible, use a real star. Using an artificial star the telescope will work almost horizontally and with a “non infinite” focus, a condition that is quite far from “real world” situations, and this will emphasize even the smallest mechanical flexure.

### The “collimation eyepiece” (Cheshire eyepiece)

The collimation eyepiece is a cheap (around 30-50\$ or €) piece of equipment that has no optics inside, excluding a 45° reflective surface with a hole in the middle. The user looks through it when the eyepiece is in the telescope's focuser.

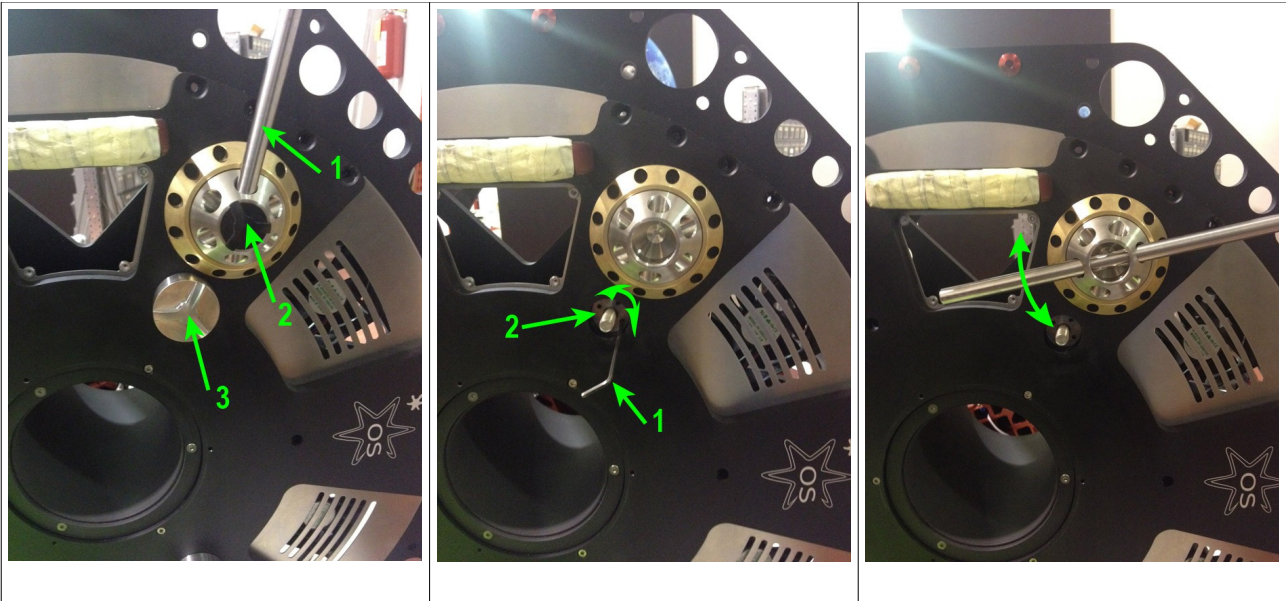
It works as the Takahashi collimator, but since it has no optics, it offers no magnification, and for this reason is more difficult to see the concentricity of the circle painted on the secondary mirror and the central black dot. This “dot” is the projection (on the secondary mirror) of the hole in the 45° mirror (red arrow in the photo at left). The photo at right was taken *through* a Cheshire eyepiece, and gives you an idea about what you see when the mirror is correctly tip-tilted.

The Takahashi collimator is obviously more precise, but a perfect collimation can be obtained even with the Cheshire eyepiece, especially if you have a very good sight!

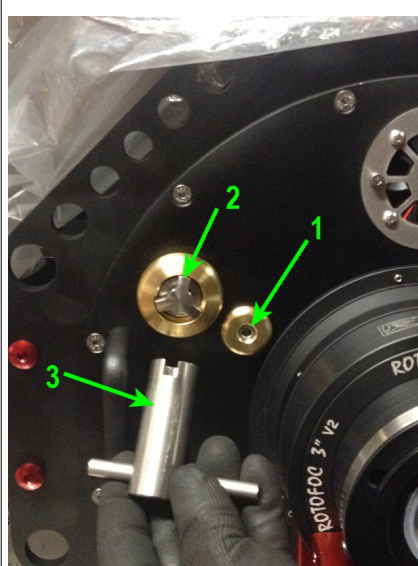


### 6.3) Primary mirror tip-tilt regulation

First of all, you must learn how to move (tip-tilt) the primary mirror. Take a look to the images in this page and familiarize yourself with the tip-tilt screws of your primary mirror.



In "big" scopes (i.e. 50 cm and above) you must follow this procedure to operate on the three big screws that control the tip-tilt movements of the primary mirror. This screws are rotated using a metal bar or a big screwdriver (1, left image). But before you can operate them, you have to remove the black cap (2, left image) and remove the external locking "bolt" (3, left image). The tool to do so has been provided with the scope. Once you have removed the external locking bolt, you will see the *internal* locking bolt (2, center image). Use a small hex wrench to move it a bit inside the scope (1, center image). Just rotate it 4-5 turns. The bolt must move *away* from the back plate, i.e. go *inside* the telescope. The big tip-tilt screw can now be operated using a metal bar or a big screwdriver (right image). Please note that even in big scopes each screw turn will move the mirror just one millimeter. Collimation screws are spring loaded (using cup springs in big scopes) so there is no need, when you tight one screw, to loose the other two or vice versa. **When you have set the tip-tilt position of the primary mirror, bring the internal locking bolt again in contact with the back plate of the scope** and put back in position the external locking bolt and the black cap. There is no need to apply too much force on the internal locking bolt. Just rotate it until it stops against the back plate of the telescope. It is the external bolt that does the real job.



In smaller telescopes there are three big screws to set the tip-tilt position of the primary mirror (number 2 in the photo at left). If your telescope has also the safety set screws (1) unscrew them 4-5 turns before to operate on the big screws using the specific tool (3), included with the scope. When you finish, tight the safety set screws. Do not apply too much force. Just let them touch "gently" the internal mirror cell.

Please note that in all Officina Stellare telescopes each collimation screw turn will move the mirror just one millimeter. Collimation screws are spring loaded, so there is no need, when you tight one screw, to loose the other two or vice versa.

There are two different procedure to tip-tilt the primary mirror.

- Using the holographic laser (needed only after a re-assembly of the scope)
- Using a star (what you are probably looking for).

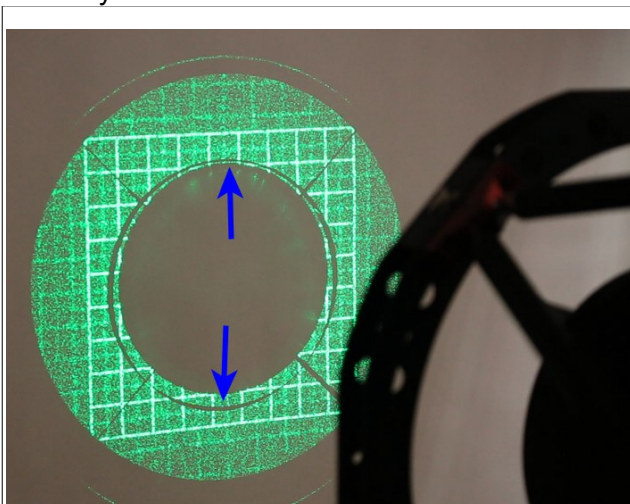
The laser does not reach the precision need for astronomical use, but it is useful for the first rough approximation after a major overhaul of the telescope. We use the laser in the factory only once, when the telescope is assembled the first time.

#### 6.4A) Primary mirror tip-tilt regulation: laser

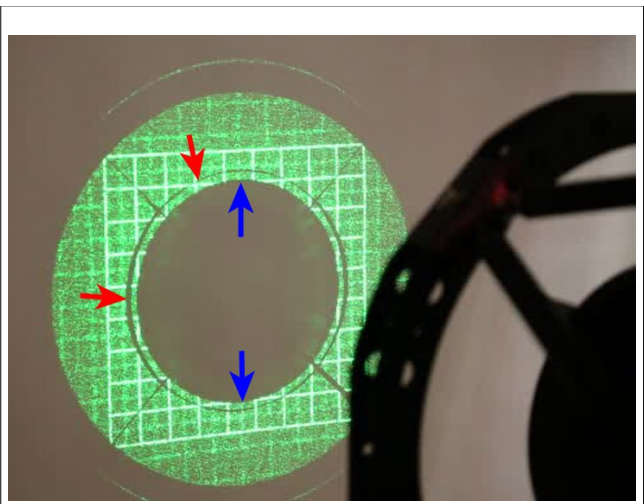
**VERY IMPORTANT:** If you have just reassembled your telescope (typically after a re-coating of the mirrors) then read this section. **Otherwise, jump to section 6.4B, “Primary mirror tip-tilt regulation: star”.**

The procedure is quite easy:

1. Install the conical flange how you have done with the Takahashi collimator, and insert the laser into the flange. Lock it in place.
2. Turn on the laser. If the laser spot hits **exactly** the middle of the circles on the secondary mirror, skip the next step and jump to point 4.
3. If the laser does not hit the middle of the "target" on the secondary mirror, tilt *the whole flange, with the laser inside*, using the push-pull screws that lock the flange to the backplate. That's the reason why there are 6 tethered holes in the flange, even if only three screw lock it to the backplate. This move may "sound strange", but it is in practice impossible to build a "perfect" laser (i.e. with the laser beam *exactly* on the mechanical axis). On the other hand, what you *really* need is the center of the beam in the middle of the secondary mirror. So the idea to tilt the flange with the laser inside has a lot of sense!
4. When the laser hits exactly in the middle of the "target" on the secondary mirror, point the scope to a wall or a big piece of cardboard, **perpendicular to the optical axis**. The distance between the scope and the wall is not relevant. Anything between 0.5 and 5 m will be ok. What is important is that you see the laser pattern projected on the wall/cardboard.
5. You will see the pattern created by the laser (circles or squares, depending on the model of your laser) and the shadow of the secondary mirror. If a “two stage” light shield is installed, you will see *two* shadows.



A telescope with a “two-stage” light shield before the tip-tilt regulation of the primary mirror. Here a “square” pattern laser is in



The same telescope after the tip-tilt regulation of the primary mirror. Please note that the shadow of the “second stage” light

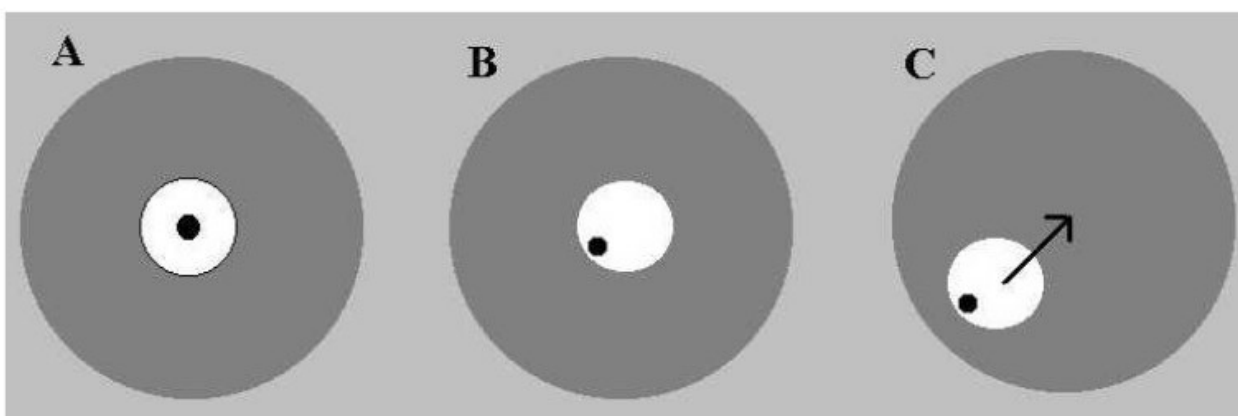
use. Note that the shadow of the secondary mirror is clearly closer to the "second stage" shadow at the "12 o'clock" position than at the "6 o'clock" position (blue arrows)

mirror may look thinner in some part and thicker in some other (red arrows). This is normal, and has no influence on telescope performance. But the two shadows are now concentric (blue arrows)

- Working on the primary mirror tip-tilt regulation screws, make the figure you see on the wall symmetric. It may sound weird, but just try to rotate a bit one screw, you will see immediately how the figure does change. Bring the shadow of the secondary mirror and the pattern created by the laser to a good level of symmetry. On the wall you can measure distances between the laser pattern and shadows of different part of the scope using a simple ruler. That's it! Now proceed to the next step, 6.4B.

#### 6.4B) Primary mirror tip-tilt regulation: star

- During night, allow the scope to reach thermal equilibrium. How long is needed for this depends on many factors, but as a rule of thumb, keep the dome open at least 90 minutes after sunset, and keep the cooling fans running for all that time. Stop the fans before to proceed. If you use an artificial star you can work in daytime, but respect the minimum distance between your scope and the artificial star (it should be stated in the instruction sheet of the artificial star). In general, the farther, the better.
- Point a bright star, high in the sky (or your artificial star). DO NOT use a 90° prism. You MUST use a star, a planet cannot be used since it is not a point-like source of light. For the same reason, there is a minimal distance between the scope and the artificial star.
- Look at the **defocused** (donuts shaped) star with an eyepiece, starting with the lowest power available (longest eyepiece focal length). If your optical train does not allow for an eyepiece to be used, use your camera instead. If this is the case, set the exposure time so you can appreciate different shades of gray in the star defocused image. Look at it a 100% zoom minimum (one pixel of the camera is one pixel on your screen); a 200% zoom is even better.
- VERY IMPORTANT. Bring the star in the center of the field of view** and look at a defocused image. If the image does appear to be "boiling", and you cannot judge if the shadow of the secondary mirror is in the center of the white circle (the defocused star), then your telescope needs some more time to reach ambient temperature, or the seeing is simply too bad to proceed. Sorry, nobody's fault! You can achieve good collimation only under "reasonably good" seeing conditions. Perfect collimation requires a perfect seeing.

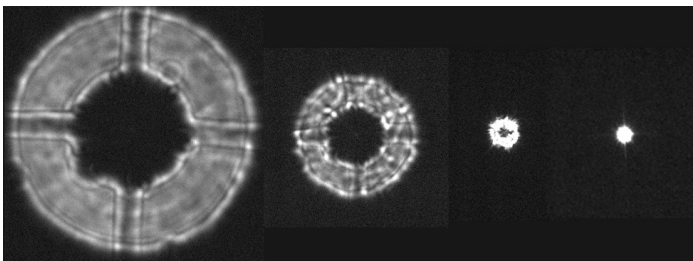


- Defocus the star until its size is about  $\frac{1}{4}$  of your field of view. Look the image above. The dark gray circle is your field of view. The white circle is the defocused star and the black spot is the position of the secondary mirror's shadow. A collimated scope will look like "A", above. We omitted the four spokes of the secondary mirror assembly for clarity.
- If the shadow is not in the middle (in our example, image "B", the shadow is at the "8 o'clock" position) then move the telescope, using the mount motors, so the image goes in

- the same direction. The defocused star must go near the edge of the field of view at the "8 o'clock" position, like in "C".
7. Try to tight or loose a bit one of the collimation screws of the primary mirror. Discover which screw (or screws) move the star image in the direction of the center of the field of view (like the black arrow in "C"). When the image will go back to the middle of the field of view, it will be more centered.
  8. Repeat steps 4-7 until you reach collimation (image "A", above). Take your time and try to do the best you can.
  9. Change the eyepiece with a more powerful one (shorter focal length) and repeat steps 4-8. For this step a magnification of around 300x is a good choice.
  10. When the image is centered and looks perfectly symmetrical at high magnification, your telescope is collimated. Proceed to the "fine collimation" procedure.

### Some hints about this procedure.

- If the dark shadow of the secondary mirror looks in the middle of the white circle, change a bit the focus, using the focuser, NOT the electric motor of the secondary mirror, if present. The white disk will became smaller or bigger. Check if the shadow is always in the middle (the human eye is a very good "device" to control if two circles are concentric). Always keep the image in the center of the field of view using the telescope mount. Focus from a "very big" to a "very small" image, and continue to check if the shadow is always in the middle of the white spot. Find the size of the spot that is more comfortable for your eye to detect concentricity. If you are using a camera you may have to change exposure time; you may also measure the single images using specific software (or a cheap ruler, working directly on the computer screen).
- If the image is too bright or too dim to see clearly the shadow of the secondary mirror, choose a different (dimmer or brighter) star, or change exposure time accordingly.
- If the shadows always look concentric even with a high power eyepiece, the collimation of your scope is "good enough" for any reasonable application. Go to the next section, "Fine collimation".



The image at left gives you an idea about what you will see during this procedure while you change focus. Here is telescope is well collimated.

Remember, always keep the star in the center of your field of view, using the telescope mount.

- It is very unlikely you have to move any collimation screw more than one turn – probably you will reach collimation with less than half a turn.
- Have someone to help you while you look at the eyepiece – or use a camera so you can see the image while you work on the screws. It is a good idea to label the three collimation "A", "B", and "C", and memorize the direction of the movement given by each screw. Obviously the star will move in the opposite direction along a straight line when you turn screw "A" clockwise or counterclockwise. Movements due to screws "B" and "C" will be 120° apart.
- In all *Officina Stellare* telescopes the collimation screws are spring-loaded using special zero-backlash cup springs, so if you tight one screw there is no need to untight the other two.
- And, very important: KEEP YOUR TIME, AND START WITH SMALL MOVEMENTS (say 1/16 of a turn). It is a good idea to mark the initial positions of collimation screws with a felt tip pen and keep track of what you do (like "screw A 45° CW – screw B CCW 30°..." and so on). Doing so, you will always be able to "undo" a wrong action.

## 6.5) Fine collimation procedure



Fine collimation is possible only under ideal seeing conditions, so you can see the Airy figure created by your scope, when you look a bright star (high in the sky!) at very high magnification (a magnification roughly equal to the aperture of your scope in mm, so 400x for a 400 mm scope).

Again, DO NOT use a 90° prism.

At very high magnification the image of each star is a bright, incredibly tiny disk of light, plus 1-2 rings of light around it. This pattern is created by *diffraction*, a physical phenomenon, and ANY good telescope will show it. The problem is that is very rare that the Earth's atmosphere is *so calm* to allow you to see the Airy figure! The use of an artificial star will allow you to see this figure more easily, but there is no guarantee (in daytime the air is much more turbulent than during night).

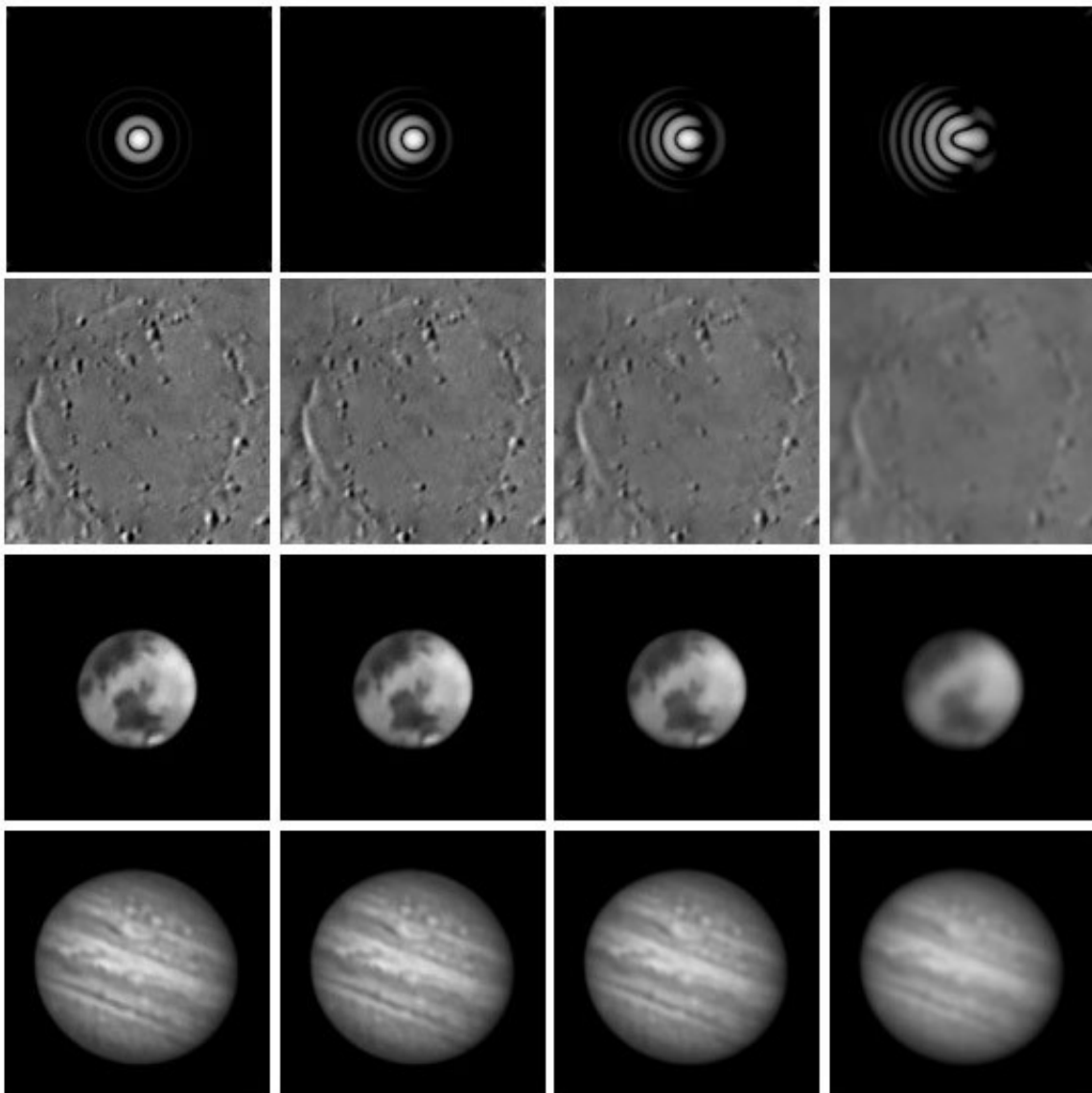
Fine collimation is achieved moving the image *toward* the brightest part of the rings. In the figure above, you see at left a perfectly collimated star. At right, the rings are brighter in the "upper" part of the image. Find the collimation screw of the PRIMARY mirror) that moves the image UP. When you bring it back in the center of the view (using the movements of the mount of your telescope), it will look more centered. Repeat the procedure until you reach perfect collimation. Fine collimation requires *minimal* movements of the collimation screws, 1/20 of turn or less.

Fine collimation is critical only for high resolution / short exposure imaging, i.e. planetary or lunar imaging. For deep sky imaging, a good "mirror's shadow" collimation is enough. The long exposure used in deep-sky imaging will always "hide" the effect of non-perfect collimation. Of course, if you have the chance to collimate your scope at his best, it is a good practice anyway! Please note that collimation is more critical if you image deep sky objects from excellent sites – where you have good seeing – and /or if you image with narrowband filters.

In the next page you see a well-known image, created by Thierry Lagault, where you can see the effect of non-perfect collimation on the Airy disk and then on the Moon, Mars and Jupiter.

Again, please note that deep-sky imaging is FAR MORE tolerant to non-perfect collimation than high resolution imaging. Even a telescope in the "worst" situation (rightmost column) would produce very good quality deep-sky images.

Only if you have an *extraordinary* seeing (Pickering scale 9 or 10) you will be able to distinguish



between the first column (perfect collimation) and the second column ("almost perfect" collimation). With a seeing that is just "very good" (Pickering scale 7 or 8) the effect of non-perfect seeing will strongly dominate over the non-perfect collimation.

Please note that a properly executed "mirror's shadow" collimation will bring you at the level of collimation of the second column. That method is not sensitive enough to reach perfect collimation. Perfect collimation requires the Airy figure. Perfect collimation without the Airy figure may happen, but it is simply... luck!

Remember: for deep sky imaging, a good "mirror shadow" collimation is enough!

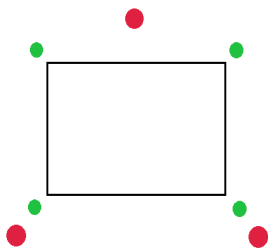
## 6.6) Focuser tip-tilt

When the telescope is ready for imaging, there are usually several parts between the telescope itself and the camera (CCD or DSLR). This "bunch" of pieces is called *the optical train*. A typical composition could be: focuser, off-axis guider, filter wheel, adaptive optics, camera. Even if all this pieces are manufactured and assembled properly, there is a chance that a minimum tilt between

the sensor plane and the optical axis exist. Such tilt can arise for different reasons, and it is normal.

You need to correct the focuser tip-tilt if your images are good along a straight line and worsen as you look farther away from that line (and the "defect" does rotate with the camera).

To correct this – and to give the user the possibility, under any situation, to reach perfect perpendicularity between the optical axis and the sensor - each Officina Stellare telescope does have 3 or 4 couples of push-pull screws to set the focuser tip-tilt. To do so, start orienting the CCD as in the figure in this page. This will help you a lot because the tip-tilt corrections will be easier to understand.



How to orientate the sensor (black rectangle) relative to the focuser tip-tilt screws, if you have three of them (red dots) or you have four (green dots).

Generally speaking, the focuser tip-tilt correction is more critical for *faster* (i.e. lower  $f/$  ratio) telescopes and *bigger* sensors. The telescope diameter does not matter.

To correct the focuser tip-tilt your telescope **must be well collimated and in thermal equilibrium with the air.** Then follow this procedure.

1. Take a 30-60 sec. Image of an area of the sky with a good number of stars (Milky Way is perfect).
2. Check if all the faint stars looks the same all over the frame. If all the faint stars looks identical, your telescope is ready for serious use. If there is a significant difference between corners, you need some trial and error to find the perfect plane. There is no practical way to know what is the first movement to try. Try "pulling" by  $1/16$  of a turn the "worst" corner. If the image is better but not perfect, pull it by another  $1/16$  turn. If it worsen, go back to "zero" first and then pull the opposite corner by  $1/16$  turn. Take trace of what you do and compare each image with the previous one.
3. When the stars looks as identical as possible over all the frame, gently "lock" all the "pull" screws of the focuser. Your telescope is ready for use!



## CHAPTER 7: THE RH "VELOCE"

The RH "Veloce" is quite different from all other *Officina Stellare* telescopes. First of all... to be precise the *Veloce* is not a *telescope*, it is an *astrograph*, i.e. an optical system completely devoted to wide field photography, with an extraordinary *f/* ratio. You can see it as the "heir" of old purely photographic instruments, like the Schmidt and the Baker-Schmidt cameras. Of course, you can take a look through it – but it is strictly designed for photography. For electronic sensors, to be precise, since it has a *wide and flat* focal plane, and an extraordinary spot size over all the illuminated field. The materials used to manufacture the RH "Veloce" guarantee negligible thermal dilatation (and focus shift) over wide temperature changes. Special "super compensated" versions are available for professional or peculiar uses. Ask us for details.



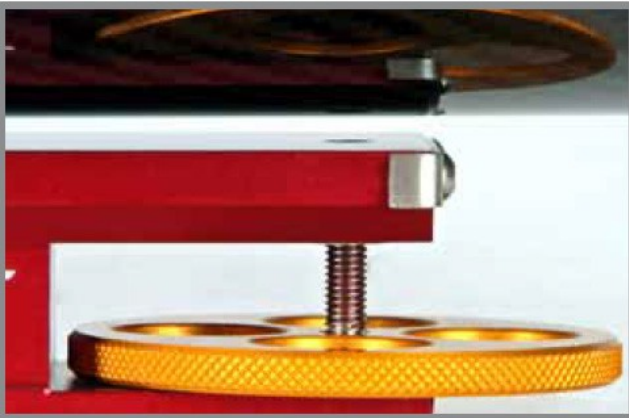


In the above sequence, you see the extraction of the hood and the primary locking screw, located "under" the scope. Also one of the two gray screws is visible in the rightmost image.

### 7.1) The light shield

In RH telescopes, the big, frontal, light shield (or "hood") was designed as an integral part of the optical design, since it works both as the entry diaphragm *and* a light baffle. For a correct use of the telescope, the light shield must be in the fully extended position. The "retracted" position is used only when you store or transport the telescope.

To extend the light shield, follow this procedure:

	<p>STEP 1</p> <ul style="list-style-type: none"> <li>• Unscrew the two locking screws (red arrows) from the back plate of the telescope and keep them aside in a safe place, ready for use.</li> <li>• Place the telescope on a stable, flat surface. If the telescope has been already placed on the mount, point 45° above horizon.</li> <li>• The external carbon-fiber hood, when retracted, is locked in place by a rubber clutch (green arrow)</li> </ul>
	<p>STEP 2</p> <ul style="list-style-type: none"> <li>• Unlock this clutch (green arrow). It works also as a locking screw for accessories on the piggyback.</li> </ul>

	<p>STEP 3</p> <ul style="list-style-type: none"> <li>The lock "under" the scope is completely open during storage or transport.</li> </ul>
	<p>STEP 4</p> <ul style="list-style-type: none"> <li>Gently slide the carbon light shield, without jerking, until the rail guide (black part) reach the steel limiter.</li> <li>Screw the locking screw (note the different position of this screw in this photo and in step 3).</li> </ul>
<p>Hole #1 (#2 is on the opposite side)</p> 	<p>STEP 5</p> <ul style="list-style-type: none"> <li>Use the two screws you removed in step 1 to lock the carbon light shield in place. Together with the "under the scope" screw, they locate 120° apart.</li> </ul>

This procedure may look a bit complex, but it is essential to guarantee the exact position of the entry pupil of the *Veloce*. This is important for optimal performance of the optics. Please note that the extended light shield is also important for the correct acquisition of flat frames, that must be taken with the light shield fully extracted, i.e. like the light frames.

For retracting the hood in the carrying position, just invert the above procedure.

## 7.2) Installing equipment at the prime focus

The *Veloce* telescopes may be bought with or without *Finefocus*, the original *Officina Stellare* focuser. If you ordered the *Veloce* without focuser, *Officina Stellare* can provide all the adapters needed to connect your equipment. Just let us know. Please remember the back focus of the *Veloce* is limited (115 mm for the *Veloce* 200). This is the primary limit for your optical train. If you

want to build some parts by yourself, technical drawings are available for free from *Officina Stellare* technical support. Just contact [support@officinastellare.com](mailto:support@officinastellare.com).

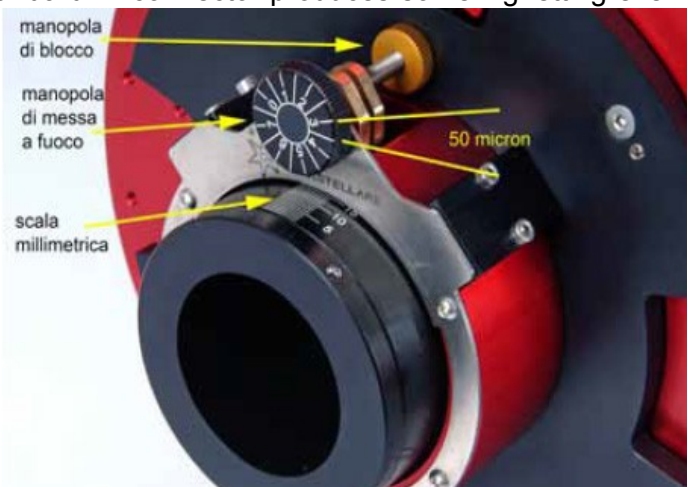
If you have the *FineFocus* focuser, here are some info and some tips about it.



The Finefocus comes installed and calibrated from the factory. It ends with a 72x1 thread, but a 2" (50.8 mm) reducer is provided, for "off the shelf" equipment (photo at left). The travel of the focuser is about 16mm and a graduate millimeter scale is clearly visible ("scala millimetrica" in the photo below). This is useful to have a reference for the position of the focus. You change focus rotating the black knob ("manopola di messa a fuoco", in the same photo). On the knob itself is engraved a reference scale with 16 marks. Rotation of the knob moves the focuser 50 microns per mark. The yellow knob ("manopola di blocco") act as a lock for the focus. This knob is positioned near the back plate at close contact with it. To lock the focus, simply screw the knob (gently!) until it stops against the plate. For unlock just unscrew leaving about 1mm of space between the knob and the back plate.

Please note that since the *Veloce* has an extraordinary f/3 focal ratio, it is possible that the standard 2" connector produces some vignetting even

on chips that are significantly *smaller* than 2" on the diagonal. This happens because the light cone that comes from the optics and illuminate the chip is quite "open". If this is your situation (or you are using a really big CCD) we strongly suggest you to ask *Officina Stellare* to create for you an adapter between the 72x1 thread and your camera. Please also remember that focus is very critical at f/3. The best image is achieved only within about  $\pm 15$  microns from the ideal focus, i.e. a focus travel that is **less than one mark on the focusing knob**.



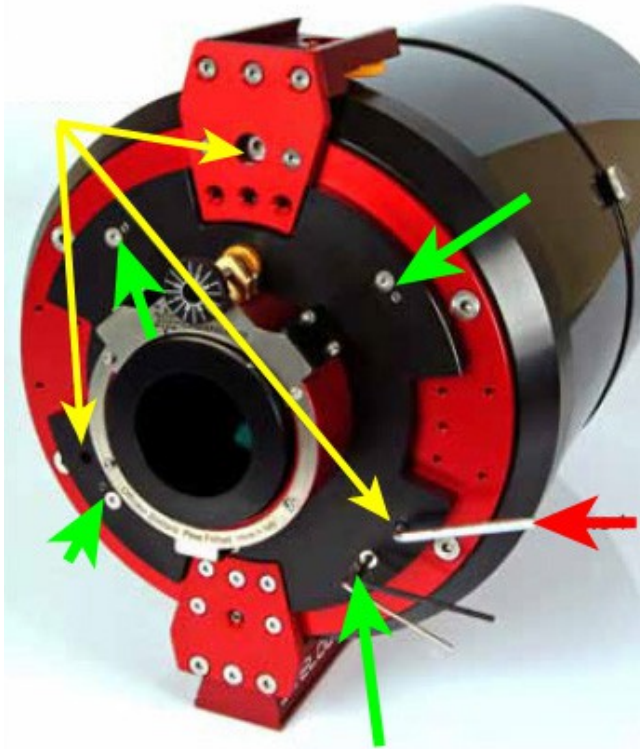
### 7.3) Installing the *Veloce* on the mount.

The *Veloce* comes with a standard "Vixen type" dovetail plate. We suggest to assemble the complete optical train (i.e. focuser, adapters, filter wheel, and camera) *before* to place the *Veloce* on the mount. With the optical train installed, the *Veloce* may became quite heavy. Have someone to help you!

The "top" piggyback mount, if present, has a standard Vixen dovetail receptacle, and is locked using the same screw that *unlocks* the dew shield. This piggyback is intended for lightweight equipment. Use common sense. We suggest not to exceed 1 kg (about 2.5 lbs). A small catadioptric guide scope or a DLSR with a light optics a typical reasonable load.

## 7.4) Collimation and focal plane tip-tilt in the *Veloce*.

To collimate your *Veloce* you have to follow a procedure almost identical to the one described in Chapter 5, i.e. you will tip-tilt the primary mirror only, working from the *back plate* of the telescope. The secondary mirror (and the frontal meniscus lens) is fixed during production. The secondary mirror shadow will obviously show no spokes.



The *Veloce* has a series of screws on the back plate that you must become confident with. See the photo at left. You see three BIGGER screws, 120° apart, for collimation (yellow arrows), and four SMALLER couple of screws, 90° apart, that control the tip-tilt of the focal plane (green arrows). Their use is described later in this section.

All the necessary wrenches have been provided with your *Veloce*. Remember, the bigger screws are for collimation, and you work on them with the bigger key (red arrow).

To collimate the *Veloce* you have to follow exactly the same procedure described in chapter 5. As a matter of fact, it is more comfortable to collimate a *Veloce* than other instruments, because you can work on the back plate *and* look in the eyepiece at the same time, the instrument is more compact, and screws are smaller and require less torque. Like in all other *Officina Stellare* telescopes, the collimation screws are spring-

loaded, so if you tight one screw there is no need to loosen the other two.

Because of the Riccardi-Honders optical scheme used in the *Veloce*, it is extremely unlikely you have to turn each collimation screw more than one turn, to reach perfect collimation. If this is the case, work on *all* screws instead of rotate more than full turn only one screw. This will preserve the distance between mirrors, that has a quite tight tolerance. Moreover, if you unscrew too much one of the collimation screws, you could disconnect the main mirror from the tube. Not a tragedy, but a big nuisance. Ask support *Officina Stellare* if this happens.

The *Veloce* is a very fast focal ratio astrograph, with a large corrected and illuminated field (42mm for the RH200). For this reason, if the optical train to the sensor is less than perfect, or the chip is not perfectly "squared" into the body of the camera (yes, it happens), you can have the unpleasant situation where the image is perfect in the center of the field, but out-of-focus or with non-pinpoint stars in one or more of the corners. In this case, you have to fine-tune the tip-tilt regulation of the focal plane. Four couples of screws are provided for this job. See section 6.6. You can do this regulation only during night time, with a series of short exposures, acting by trial and error. Each couple of screws does include a "locking" screw (the smaller one) and the spring-loaded regulation screw (the bigger one). Look the photo in this page (lower green arrow). The black hex key is in the regulation screw, the thinner bright one is in the locking screw.

You must unlock all the four "locking" screws, do your trial and error with the four regulation screws, and then lock again the tip-tilt mechanism, locking (gently) the four locking screws

**WARNING: this procedure requires just small movements, for sure under one full turn of the screws. Do not unscrew the orthogonality adjustment screws too much, as the focuser or the attached optical train may disconnect from the tube.**

## CHAPTER 8: CARE AND CLEANING OF YOUR TELESCOPE

The golden rule of optical cleaning is:

DO NOT CLEAN YOUR OPTICS TOO OFTEN!

Some dust, a few resin droplets or a small fingerprint will NOT affect the telescope performance. Even giant professional optics usually look "horribly dirty". It is much more risky to clean the optics too often or in an improper way than to use a "reasonably dirty" optics.

### 8.1) Care of the structure

If used properly, your *Officina Stellare* telescope will last decades. To clean any part (excluding the optics, i.e. mirrors and lens), simply use a soft piece of tissue that leaves no hairs. If needed, a mild detergent, in very diluted form (i.e. 100:1 with water) may be used. Dry all surfaces after cleaning, and power down the electronics before to clean the scope. Avoid the use of aggressive detergents or solvents. They could damage the finish of the metallic parts, or even damage the carbon fiber parts.

### 8.2) Clean the lenses

Lenses are present in your telescope only in the corrector group (if present) or as the front meniscus in RH ("Veloce") models. Usually the only dirt you find on them is simply dust. To remove dust, use a camel's-hair brush, available in any camera shops. Don't buy the cheapest you find. More expensive models will be the ones with the softer hair. Use the brush very gently. Remember to keep the brush clean! Store it its box or (better) a small reclosable plastic bag. If the the brush has an embedded "pump", like the one in the photo at right, "blow" many times for any stroke of the brush. Be as gentle as possible. Move the brush radially, from the center of the lens to the border.



A can of compressed air is also ok. Choose one with no liquid propellant. Liquid propellant cans may "spit" on the lens, and this would made the situation worst! The absence of liquid propellant is usually clearly marked on the can itself. Also an air compressor WITH A GOOD FILTER is ok. You can "filter" the air flow also with some layers of medical gauze.

For tougher dirt or stains, use a lens-cleaning solution and lens-cleaning pads or tissue, all available in camera shops. The best detergent is pure isopropyl alcohol, usually available in pharmacies. Avoid "lens pens" with a soft, retractable, solvent-impregnated tip. They are designed for small lenses (i.e. eyepieces, glasses, microscopes...).

When cleaning lenses, apply fluid to your cleaning pad, not to the lens itself. Rub as gently as you can an take your time. Move slowly. Use short, radially oriented shots (from the center of the lens to the border). Change the pad frequently. Use latex gloves and ventilate the room (isopropyl alcohol is a mild irritant and almost all cleaning lens solutions include it).

Remember: FIRST remove the dust, with camel-hair brush and/or air can, THEN (only if really needed) rub the lens with detergent.

If your telescope is used and stored properly and if your observatory is not in the middle of a woodland (where resin droplets are inevitable) it should be really unusual to go beyond the "camel brush and compressed air" level. Remember, even if the color of the lens coating changes a bit, has a local "flourish" or a small scratch, this has no detectable effect on telescope performance.

### 8.3) Clean the mirrors

**Before you start...:** Are you sure your mirrors really needs cleaning? It is not easy to give a general rule, but a mirror has to look really "horrible" before you notice *any* performance degradation. The mirror at right, for example, is a reasonable candidate for cleaning with air, but not for a "bath". As a very general rule, a mirror requires cleaning every 100-300 hours of use, but this number is strongly dependent on conditions.



Anyway, do not expect the performance of the optics to change significantly just because of cleaning!

**We suggest to clean your mirrors ONLY WITH COMPRESSED, FILTERED AIR, LEAVING THEM IN PLACE IN THE TELESCOPE STRUCTURE. A compressor with a good filter is a safe, good and fast solution for "regular" dirt and dust. You can use cans of compressed air (with no liquid propellant). Only if you think your mirror needs a stronger action read further – and proceed AT YOUR OWN RISK. Damages due to improper cleaning are not covered by warranty**

To wash your mirrors have handy the following equipment:

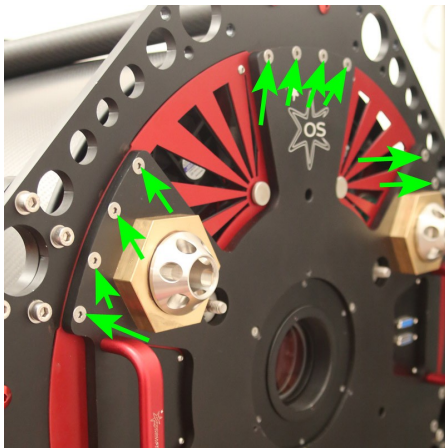
- Distilled (de-ionized) water (buy a couple of 2-liter bottle)
- Air blower (can with no liquid propellant or an air compressor with filter).
- Kitchen transparent film and paper tape.
- Latex gloves and a mask (to avoid spitting on the mirrors)
- Sterile cotton . You can buy it in a pharmacy. You need sterile cotton since it's more likely to be grit free (there are no "microscopic sand grain" in it).
- A solution of 100:1 diluted mild dish detergent in distilled water, if needed (see procedure)
- A water atomizer (see photo at right) with distilled water, if needed (see procedure). Buy a model that permits also water "jets", not only atomization.
- A lot of paper towels (the roll you usually have in the kitchen is ok). You will use them to dry the excess water from the mechanical part of the cell – not from the mirror itself.



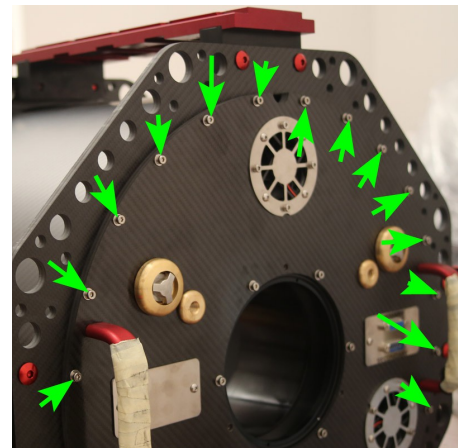
To work on the primary mirror, you will need to disassemble the cell from the structure of the telescope. Simply unscrew all the screws that keep the cell in place. Before to do so:

- "Lock" very hardly the telescope mount. When you remove the primary mirror, the telescope is totally unbalanced! In equatorial type mounts, point the scope to the pole. In alt-az mounts, point to the zenith. This position will limit the stress on the mount when you remove the primary mirror cell.

- Be aware the primary mirror cell, with the mirror inside, may be really HEAVY. Don't try this procedure while you are alone. Use the proper lifting equipment, if needed.
- In all telescopes, there are electric connections inside. Gently unplug them while you remove the cell, and remember to re-plug them while you reassemble the cell in place.
- The number, position and "look" of the screws that fix the primary mirror cell to the tube may vary with the size and optical configuration of each scope, but such screws are always a very regular "crown" around the optical axis. Because of the big number of screws, there is no risk of misalignment when removing or reassembling the primary mirror cell.



Two different "backs" of *Officina Stellare* telescopes. As you can see, the screws that fix the primary mirror cell to the tube look different (green arrows), but the symmetry of their arrangement around the optical axis is obvious.



### Procedure:

The mirror itself is made of glass, so it is very hard. What is delicate is the surface coating (aluminum, silver, or gold, plus protection coatings, depending of the telescope purpose). Since any kind of dust does contain some microscopic piece of "sand", the risk is to scratch the coating, not the mirror.

When you wash a small mirror, you simply remove it from the cell and put it in the sink. Then you blast it with water. The mirrors of *Officina Stellare* telescopes are too big to operate this way, and we suggest *not* to remove the mirror from the cell. So we will describe the procedure to wash the mirror *without* removing the mirror itself from the cell, but just removing the cell from the scope, as described above.

1. Remove the cell+mirror assembly form the tube, as described above.
2. From now on wear LATEX GLOVES AND A MASK.
3. PROTECT THE LIGHT SHIELD AND THE ELECTRONICS USING KITCHEN TRANSPARENT FILM. Try to leave only the mirror exposed. The paint over light shields is really delicate. Don't touch it with naked hands.
4. Put the cell+mirror assembly horizontally (i.e. optical axis parallel to the ground), and provide some way to drain the water you will blast on it.
5. Use an air blast (from an air can or from a compressor) to blow the bigger dust away. DO NOT USE BRUSHES – only air.
6. If the mirror looks good enough to you, stop here and reassemble the mirror+cell in place. Continue this procedure only if you have dust that remains attached to the mirror, or you have "greasy" dirt (fingerprints, resin droplets).
7. Mask, if needed, electric or mechanical parts with paper tape to protect the from water blasts (if needed, you can stick the paper tape to the *side* of the mirror, obviously *not* on the reflective surface).
8. Use the water atomizer (loaded with distilled water) to produce small "jets" of water against the reflecting surface of the mirror. The cleaning action is purely "mechanical", i.e. is the

- water jet that does remove the dust. There is no "chemical" action at this stage. You will use something else than water only if needed (see below).
9. Clean all the mirror 2-3 times with water jets. Rotate slowly the mirror and blast only the "lower" half, to facilitate the drain of water. Tilt a bit the mirror so that the water flows in the drain without the risk to touch electrical or mechanical parts of the cell.
  10. After this "shower" your mirror is probably clean enough. Just let it dry in open air. Use a hairdryer to speed the process, if needed. Keep the hairdryer at least 40 cm from the mirror. If the temperature of the air flow can be regulated, use the lowest setting.
  11. Should you have fingerprints, resin droplets or other "greasy" dirt on your mirror, use a mild dish detergent, heavily diluted with distilled water (100:1) and pour it on some sterile cotton. Wear latex gloves to avoid the grease from your own skin. Gently DUB (and not RUB!) the mirror surface with the cleaning solution. Change often the cotton.
  12. Wash the mirror again with plenty of water jets from the atomizer, like in step 8 and 9. Let it dry in air or with the hairdryer.

Remember. If the water jets are not enough, the general idea is to "dub without rub" with the detergent solution. Rubbing (even as gently as you can) will almost surely leave some scratches on the mirror coating. Generally speaking scratches are not a problem – a mirror will work fine even with dozen of them – but the problem is that a *single* "bad" scratch can create annoying reflexes when imaging with a bright star in the field. If you have to act really energetically (like for a bird poo... yes, it happens!) keep the dirt wet while rubbing (with wet cotton, gently). Grit is less abrasive wet than dry, so "the wetter, the better". Use a lot of water!

For **secondary mirrors**, we suggest to wash them with the same procedure, but without removing the cell from the tube. It is a good idea to wash the secondary mirror when the telescope is pointing at the zenith, and the primary cell has been removed for cleaning. Since all secondary mirrors are "sealed" against their cells, and you spray water upwards, there is no risk of water to go "behind" the mirror, where the electrical parts (mirror heater and secondary mirror motor, if installed) are located. Remember to protect the light shield with transparent film, and always wear latex gloves.

NOTE: because of the orientation of mirrors during use, it is normal to clean the secondary mirror only every two or three cleanings of the primary mirror.

#### **8.4) Re-coating the mirrors**

And what about *re-coating* of the mirrors? The sad reality is that there is no general rule. The mirror coating may need to be redone every two years or so, if your telescope is located in front of the sea, in a very polluted area, and works 350 nights every year. The same coating will last 10-12 (or even more!) years if your site is high in the mountains and in a low pollution area, and/or the telescope is used less frequently.

If you need assistance to disassemble the mirrors from their cells for re-coating, please contact our customer service, [support@officinastellare.com](mailto:support@officinastellare.com), because there are dozen of different cells models, so we will e-mail you specific instructions for your scope.