REFRACTORS

General information and tips

Contents

WARNING!

Never look at the sun with a telescope or any other optical device. Permanent and irreversible damage would be done to your eyes, which could lead to blindness.

For solar observation, there are special solar filters that are mounted in front of the front lens of the telescope. Please also consider the small finder scope, which must also be covered or equipped with a solar filter.

Do not use eyepiece solar filters, as they may crack and cause you to lose your eyesight.

Also, please do not use the telescope for solar projection. The heat generated inside may destroy the telescope/eyepiece.

Never leave the telescope unattended, especially when children are around. They could endanger themselves and others through lack of knowledge.

Only use the telescope for the type of observation described in these instructions.

Refractor designs

A distinction is made between achromats, ED apochromats and apochromats. The designations refer to the construction of the objective of the refractor.

The achromat consists of two lenses, between which there is typically an air gap (Fraunhofer design). Because of its simple construction, an achromat is inexpensive and has the advantage of adapting quickly to the ambient temperature due to the small amount of glass.

With achromatic refractors, especially those with a short focal length in relation to the objective diameter, a color fringe becomes visible on object contours with bright objects (= strong contrasts), which can be disturbing.

Every optical lens exhibits color errors to a greater or lesser extent. These occur because different wavelengths are refracted to different degrees. In practical observation, this leads to more or less pronounced color fringes, depending on the type of glass and number of lenses.

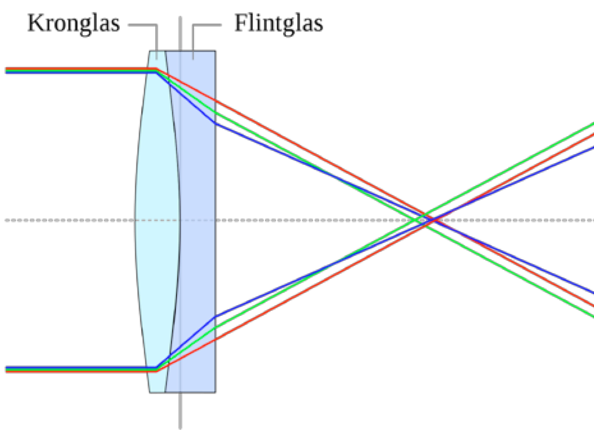
To minimize these errors, special types of glass are used and/or systems of three or (rarely) more lenses are constructed.

Between the simple achromats and the complex apochromats with very low chromatic aberration, there are the so-called ED apochromats, semi-apochromats or half-apochromats, which, thanks to special types of glass, achieve a better imaging quality even with a two-lens objective.

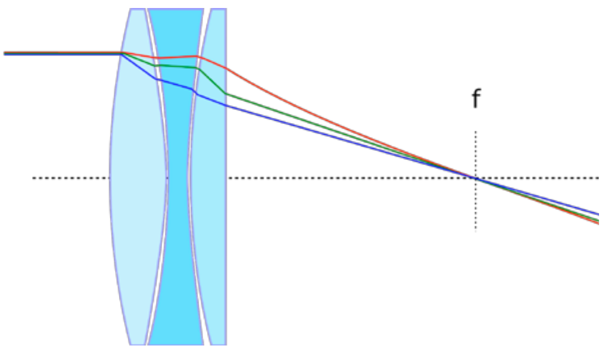
The color error correction is not on the level of apochromats, but it is much better compared to achromats.

Apochromatic refractors reduce the chromatic aberration to a very significant level, often below the perceptibility limit. This is achieved by using special glass and a setup of three or more lenses.

Achromatic Refractor



Apochromatic Refractor



Imaging quality

Like every optical system, the objective (lens system) of a refractor must be correctly adjusted to achieve the best possible performance (imaging quality).

It is essential to know the properties of the respective telescope in order to be able to judge whether the image still corresponds to the technical possibilities or whether an aberration is already present.

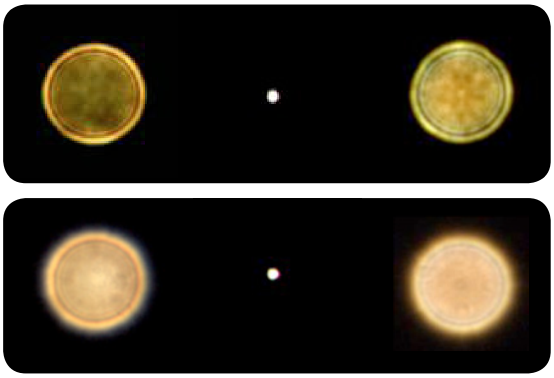
A simple check is the so-called star test.

In this test, the diffraction pattern just outside the focus is compared with the diffraction pattern just inside the focus (intra- and extrafocal) at high magnification.

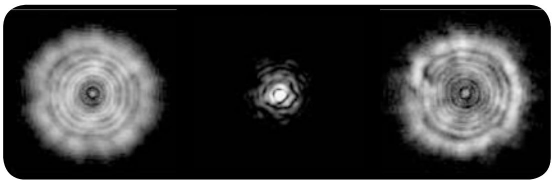
A perfectly adjusted refractor shows an (approximately) identical and error-free diffraction pattern in both positions.

Examples

The sample images were taken on an optical bench. An artificial star was used.



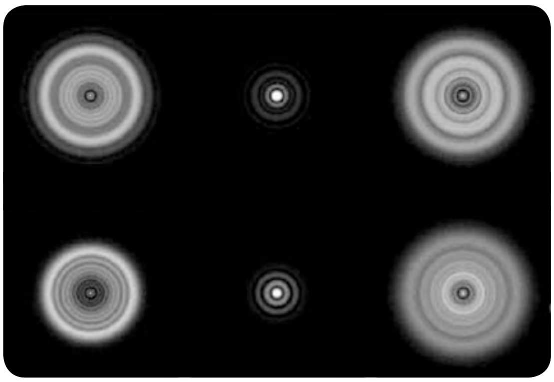
When adjusting on the natural star, the image is affected by seeing.

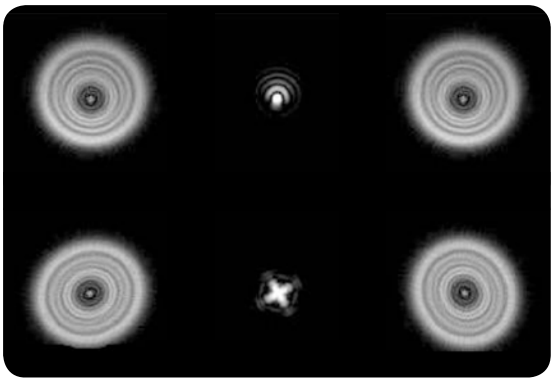


Typical error patterns

Zone error

Coma





Spherical aberration

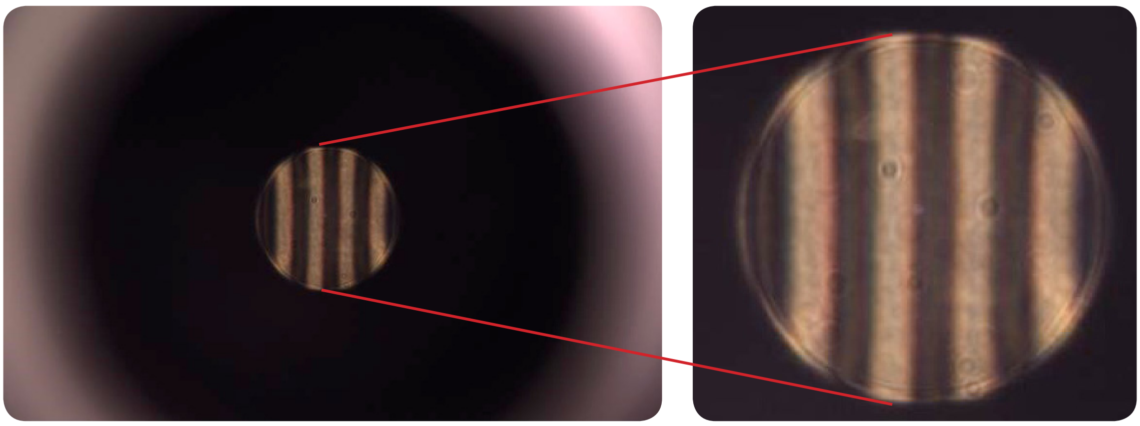
Astigmatism

Checking the optics with a Ronchi eyepiece

The Ronchi test also checks the image outside the focus.

The resulting fringe pattern is undistorted in a perfect objective and has sharply defined light-dark transitions.

Practically every objective will show more or less pronounced deviations. The type and strength of these deviations from the ideal representation indicate the type and strength of an existing defect.



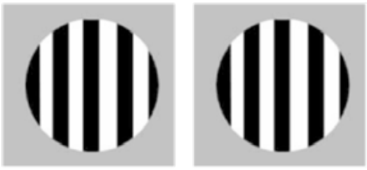
Typical error patterns

A large number of optical errors can be detected by means of the Ronchi test.

The illustration on the next page shows the most important/most frequent errors.

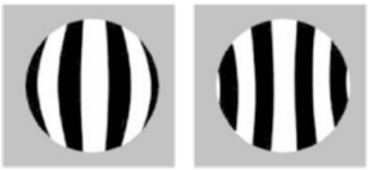
Ronchi test: typical error patterns

intrafocal **extrafocal**



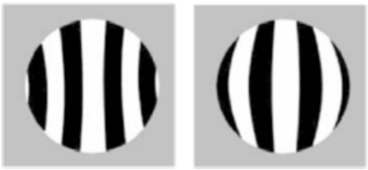
Perfect optics

Intra- and extrafocal image are identical; no deviations from the ideal image are visible.



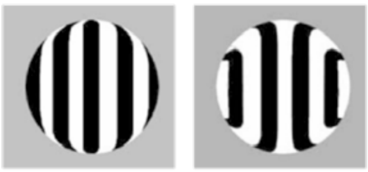
Spherical overcorrection

The focal point changes with the distance to the optical axis. Diffraction rings become visible, the contrast decreases.



Spherical undercorrection

Like spherical overcorrection; only different error direction.

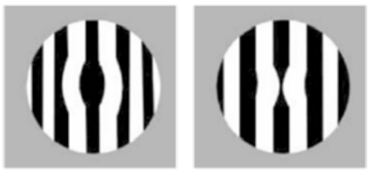


Lowered edge

Effect similar to spherical overcorrection. Error is particularly troublesome with bright objects. A ring diaphragm can reduce the disturbing influence.

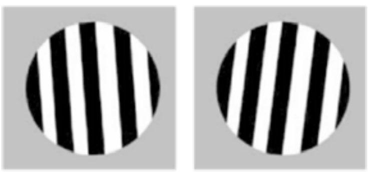
Central elevation

Because of the small area fraction, the effects are less severe than for other errors. For reflecting telescopes with central obstruction, the error has little to no effect.



Central lowering

Like central elevation, only different error direction.



Astigmatism

There is no clearly defined focal point, but an elliptical distortion of circular light sources. The axes of the ellipses in front of and behind the focus are twisted together by 90 °.

Zone error

Annular deviation from the ideal shape. A more or less pronounced zone error almost always occurs during production.

Collimating/adjusting a refractor

You can collimate a refractor with a Cheshire collimating eyepiece. Note that not all refractors have an adjustment facility.

Procedure

Cover the objective with the dust cap and insert the collimating eyepiece into the focuser.

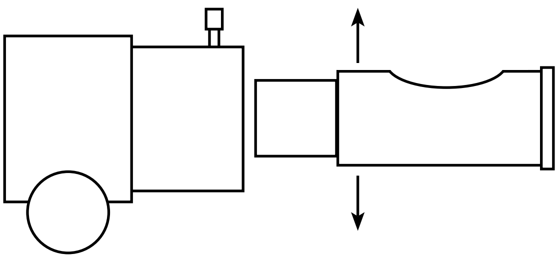
Point the side opening of the eyepiece towards a sufficiently bright light source (daylight, flashlight, etc.).

The light is directed into the telescope via the mirror located in the collimating eyepiece and reflected there by the lens surfaces of the objective.

Each glass surface of a lens group facing the eyepiece generates a reflection. When looking into the eyepiece, these reflections can be seen as rings. In a perfectly adjusted objective, all rings are concentric.

If the objective is not correctly adjusted, you should first check whether the position of the entire objective assembly needs to be adjusted or whether the individual lenses within the objective are out of alignment with each other.

To do this, remove the eyepiece from the focuser and move it a few millimeters perpendicular to the optical axis in front of the focuser in different directions (horizontal, vertical and diagonal) as shown in the illustration below.



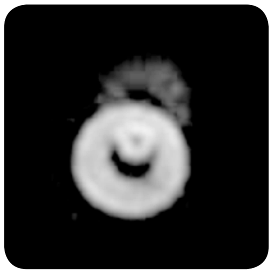
If you find a position where all rings are concentrically imaged, the lens assembly as a whole must be adjusted.

If you cannot get a correct image of the rings in any position, most likely at least one lens within the objective is out of alignment.

In this case you should ask the supplier or manufacturer of the telescope for help, because adjusting lens systems requires special tools and a lot of experience.

Since the test is very sensitive, overlapping of the rings is sufficient to achieve good imaging quality. The more precisely the rings lie inside each other, the better the imaging quality.

de-aligned refractor



sufficient
adjusted refractor

If the objective of your refractor is adjustable via pull/push screws, you can determine which adjustment screw must be adjusted to eliminate the error by moving the adjustment eyepiece sideways.

Be careful not to apply pressure to the lens system. If an adjustment screw needs to be tightened more, the other screws may need to be loosened slightly.

Storage and transport

For storage, the dust cap should be placed on the objective and the focuser retracted completely to prevent the buildup of dirt and dust on the optics and moving parts.

When storing or packing the refractor, be sure to protect the knurled knobs of the focuser from shock and pressure.

Maintenance and cleaning

If the telescope needs to be cleaned, it should always be done with extreme care and the proper cleaning materials.

Some important rules:

• Clean the telescope as infrequently as possible. After too frequent cleaning, the imaging quality of the telescope will increasingly suffer. Some dust or similar minor dirt on the optics does not negatively affect the imaging quality. Only when the optics are really heavily soiled should they be cleaned. It is recommended not to clean a telescope more often than once a year.

• The **only exception** to this rule: fingerprints and pollen from flowers can attack the coating of the mirror or lens. In this case, the optics should be cleaned.

• Store the telescope only with the dust covers attached. This is the best way to prevent dust from accumulating on the optics.

• It is best to remove dust on the optics without touching it using a bellows (available in our online store).

• To remove fingerprints, pollen or dust that cannot be removed with a bellows, you may ONLY use special cleaning agents, such as so-called „Lenspens“ (for eyepieces) or special microfiber cloths (for telescope optics). However, since this type of cleaning cannot be done without contact, it should be done as infrequently as possible.

• If you do not feel confident to clean the optics, you can contact our customer service.

Useful magnifications and calculation formulas

The magnification in a telescope is calculated by dividing the focal length of the telescope by the focal length of the eyepiece.

Example:

Telescope focal length 700 mm

Eyepiece focal length 12.5 mm

700/12.5 = 56x magnification

This means that the **smaller** the eyepiece focal length, the **higher** the magnification.

With a 2x Barlow lens, the magnification doubles, in the example to 112x.

Examples for a telescope with 700 mm

Focal length (eyepiece focal length/magnification/magnification with 2x Barlow lens):

20 mm	35 x	70 x
12.5 mm	56 x	112 x
4 mm	175 x	350 x

Highest and lowest useful magnification

Theoretically, almost any magnification is possible with a telescope if you use the right eyepieces. As you can see in the table above, in the example with the 4 mm eyepiece and a 2x Barlow lens even a magnification of 350x can be achieved. With even smaller eyepiece focal lengths and stronger Barlow lenses (e.g. 3x, 5x) this could be increased almost arbitrarily. However, the useful magnification range is limited by the laws of optics.

For the highest useful magnification, the rule of thumb is that you should choose a maximum magnification of twice the diameter of the optics.

For example, if the telescope has an diameter of 76 mm, the highest magnification should the highest magnification should not be more than 76 x 2 = 152x. If you go beyond this range, the image will become dark and the sharpness will decrease, so you will see less detail despite the higher magnification.

Magnification is also often limited by what is called „seeing“ (air turbulence in the Earth’s atmosphere).

Depending on the night of observation, the air may be calmer or less calm. The highest useful magnification can only be achieved when the air is as calm as possible.

The lowest useful magnification is limited by the so-called exit pupil (EP). The exit pupil is the diameter of the light beam that is directed from the eyepiece into your eye.

Here’s how to calculate the exit pupil:

Aperture of the telescope / Magnification

= diameter of theexit pupil

If the exit pupil is larger than the pupil of your eye, light is lost and the image becomes darker. It is believed that the human pupil dilates to a maximum diameter of 5-7 mm in complete darkness. Therefore, avoid magnifications that result in an exit pupil that is too large.

Examples (aperture of the telescope and lowest reaonable magnification):

60 mm	8,5–12x
70 mm	10–14x
76 mm	11–15x

Observing with the telescope

1. Always set up the telescope outdoors. It is best to place the telescope outdoors about 30 minutes before observing so that the optics can adjust to the ambient temperature. Observing from inside a building through a window (whether open or closed) is not recommended, as the image quality deteriorates significantly due to air exchange.

2. Choose a location for observation that is as dark as possible. This is especially important if you want to observe faint objects such as star clusters, gas nebulae, or even galaxies. Spend some time in the dark before observing to give your eyes a chance to adjust to the dark. Avoid looking directly into bright light, as this will undo the dark adaptation. Use a red light lamp that is not too bright for orientation at night.

3. Remove the dust caps from the telescope before observing. On some telescopes (e.g., 76/700 mm Newtonian telescope), the cap is in two parts. Remove the entire cap, not just the inner part.

4. Always use the eyepiece with the lowest magnification first. Once you have centered the observation object in the telescope, you can slowly increase the magnification.

5. During observation, moisture (dew) may condense on the optics. If this happens, DO NOT clean the optics with a cloth as this will damage the optical surfaces. Instead, you should warm the optics slightly, e.g. with a hair dryer or with optionally available exchange heaters. Slight heating is completely sufficient! The optical elements must not become hot under any circumstances!

6. If you bring the telescope back into a closed room after observing, dew can form on the surface due to the difference in temperature and humidity. Short-term dew condensation is not a problem. However, the telescope should not be stored in a damp condition. Leave it open (without the dust cover) for about 1 hour until the optics have adjusted to the room temperature again and the moisture has disappeared. Only then should you place the dust covers on the telescope aperture and the focuser.