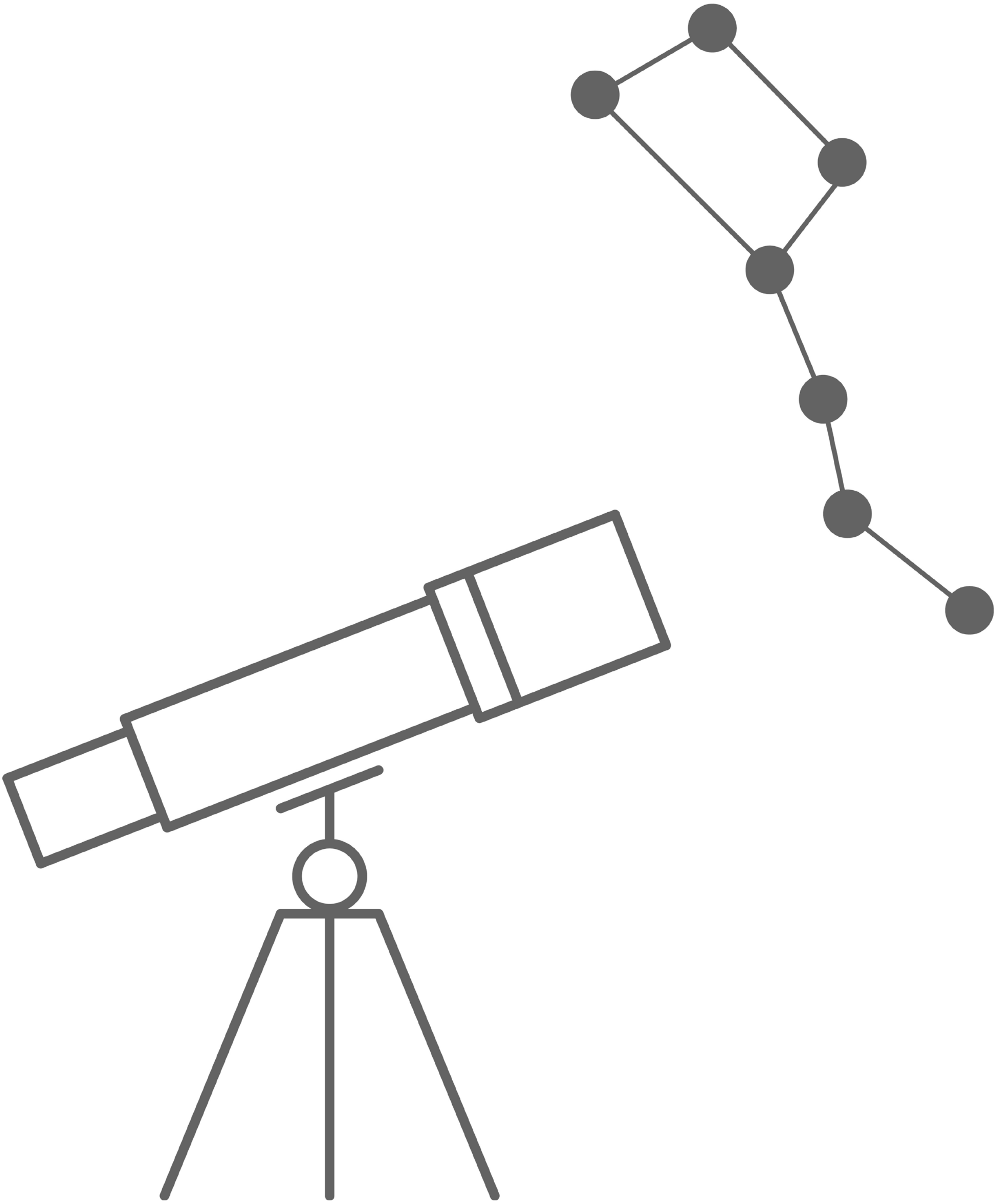
DÖRR

TIPS & TRICKS



FOR ASTRO OBSERVATIONS

⚠ CAUTION!

- **NEVER look directly at or near the sun through the telescope or finder scope! There is a risk this could cause blindness!**
- **The telescope is not a toy! Children must not use the telescope without adult supervision.**
- **Please note that the light appearing through the eyepiece is strongly bundled and can develop a great heat. Therefore, make sure that the telescope is not directed at easily flammable materials.**

EXPLANATION OF THE MAIN TERMS

Astrophotography

Using the astrophotography method, light is accumulated on a film layer (exposure time), while when carrying out direct observation only the momentary incidence of light is registered. 2.5 further stellar magnitudes can be observed in comparison with observation with the naked eye (see the chapter on image brightness). Celestial photography can be carried out in three different ways:

1. Wide area photography

The telescope and its mount serve only as a follow-up aid. The existing camera is mounted parallel to the viewing direction of the telescope. It does not matter how the camera is secured. The only important thing is to restore its weight balance. This method is mainly used to photograph larger sections of the sky (star clusters, star fields, nebulae, etc.).

2. Focal photography

In focal photography, both the camera objective and the telescope eyepiece are removed. The image generated by the telescope lens is projected directly onto the film plane of the camera. The camera is attached to the eyepiece extension tube using an adapter.

3. Projection photography

Projection photography is used when the image of the focal photography appearing on the film is too small, for example when photographing the planets. With the help of an eyepiece, the image is projected greatly enlarged onto the film of the camera.

Resolution / resolving power

The resolving power is an important quality feature of any optic. It indicates whether and how well two closely adjacent stars can be individually recognised. This depends crucially on the lens diameter (mirror diameter) of the telescope. The resolving power is given in arc seconds. This is the distance between two stars in arc seconds **(1 degree = 60 arc minutes = 3,600 arc seconds)**. The resolving power is calculated using the following rule of thumb:

Resolving power = 13.8 arc seconds/lens diameter (in cm).

Example: Objective diameter = 114 mm results in a resolution of 1.21 arc seconds.

Exit pupil

The exit pupil A_P is the small image of the entrance pupil E_P projected through the eyepiece into the image plane (eye), which in a telescope is the lens diameter (diameter of the main mirror).
The ratio between the entrance pupil and the exit pupil is the magnification, i.e. $E_P / A_P = V$.
The exit pupil arises just behind the eyepiece where the eye is.

The magnification V depends on the size of the exit pupil. The telescope exit pupil is usually larger than the pupil of your eye, which restricts your field of view. The size of the pupil of the eye depends on your age. The following values can be applied:

Age:	10	20	30	40	50	60	70	80
Pupil size in mm	7	8	7	6	5	4	3	2.3

Brightness

In the case of point-like objects such as fixed stars, the image brightness depends almost exclusively on the size of the object. However, there are also subjective terms to take into account, such as the quality of the observer's vision. The following formula can be used to determine the limits of magnitude of stars that can just about be seen with the telescope: $m = m' + 2.5 \log. (D/A)^2$

Where:

D = diameter of the objective
A = diameter of the exit pupil
m = limit size of the telescope
m' = limit size of the naked eye

Let us take the example of a youngish observer, who can just about see stars to the 6th order of magnitude with the naked eye (m' = 6.0). For a reflector telescope with an aperture of 114 mm, the limit size of the stars to be observed is calculated as follows: m = 12.4 mag

The limit values determined in this way are normally not reached, as they are weakened by the atmospheric conditions and many other, constantly fluctuating influences, and also the eyes of the observer.

Entrance pupil

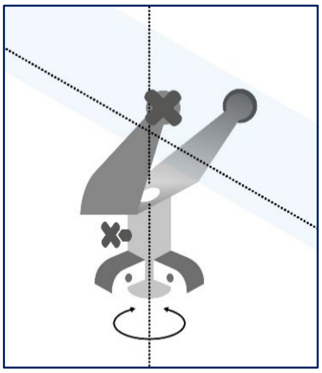
The entrance pupil is the entrance surface of the light entering the optical system. In the case of a reflecting telescope, this is the area of the main mirror.

Mounting

The astro telescope is set up on a mount. This serves to affix the telescope but above all to track the apparent movement of the sky. We differentiate between 2 types: **Azimuth mount and Equatorial or parallactic mount.**

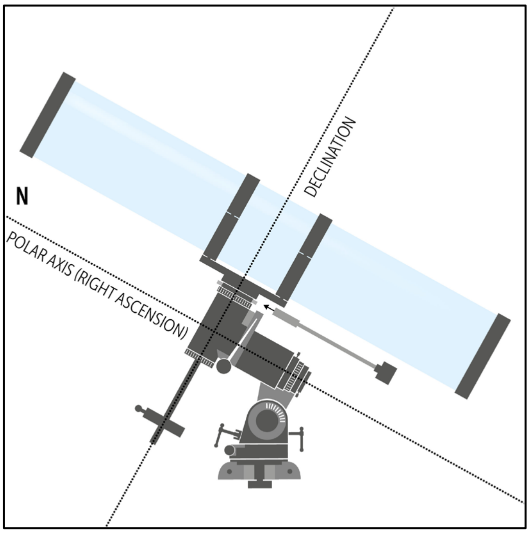
Azimuth mount

Usually found in smaller telescopes, this is a kind of fork mount that requires vertical and horizontal tracking by hand. A little practice is required for exact tracking and setting.



Equatorial mount/parallactic mount

This consists of 2 axes: the pole or hour axis (right ascension) and the declination axis for the coordinate setting of the respective object being observed. These axes are at right angles to each other. The right ascension axis points to the celestial pole and is parallel to the earth axis.
Set the desired observation object on the declination axis. The telescope is attached to the declination axis. This in turn runs at right angles to it and parallel to the polar axis.
The equatorial mount can be adjusted to the local pole height/latitude. The apparent movement of the sky is then only tracked via the polar axis. A balance weight on the declination axis ensures that the telescope is balanced.



Tracking

The polar axis of the telescope must correspond to the rotation of the earth so that the celestial vault appears to be fixed. To achieve this, the hour angle (right ascension) must be corrected with the help of a flexible shaft (manual and uneven movement) or a tracking motor (continuous and even, therefore essential for astrophotography).

Objective

An objective is a lens or mirror system facing the object to be observed, which is used to project an intermediate image in the image plane. This image can then be viewed by the observer through an eyepiece. The objective is one of the most essential parts of a telescope and is decisive for its light intensity and image quality.

Eyepiece

Optical lens system for viewing and magnifying the image generated by the lens (in the focal point in the case of telescopes). Eyepieces for astro telescopes are inserted into the eyepiece holder. They are either 1 or 1 1/4 inches in diameter.
Basic types available from DÖRR:

Huygens eyepiece

Plano-convex crystalline lens and plano-convex field lens. The field of view is between 20° and approx. 35°. The Huygens eyepiece is colour corrected. It is unsuitable for short focal lengths and large focal ratios. The eye must be brought very close to the crystalline lens. Danger of contamination by eyelashes. This eyepiece is relatively cheap to manufacture.

Mittenzwey eyepiece

Improved Huygens eyepiece with a field of view of 50°.

Ramsden eyepiece

Two plane convex lenses with the bulbous sides facing each other. Field of view of between 25° and 35°.

Kellner eyepiece

Improved Ramsden eyepiece. The crystalline lens is an achromatic double lens that shows hardly any chromatic aberration and the curvature of the field of view is also greatly reduced. Face distance approx. 40° and almost free of distortion.

Orthoscopic eyepiece

High colour purity consists of 4 lenses. The image field plane lies in front of the field lens (where the shutter is also located). The distance between the eye and the lens is greater, so there is no contamination by eyelashes. Own field of view: 40° to 45°.

Plössl eyepiece

Achromatic lens system consisting of two almost symmetrical achromatic doublets. Own field of view between 40° and 50°.

Solar filter

The energy in the beam path of the solar image is so powerfully bundled that it is essential to protect the observer's eye and the optical devices in the telescope. The best way to do this is to attach neutral filters or to stretch suitable foils (e.g. 2-3 layers of a rescue foil) on the light entry apertures of the telescope. Sun filters that can be screwed into eyepieces only protect the eye, not the device.

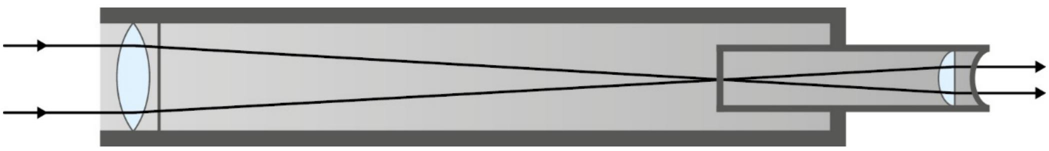
ATTENTION: such filters may crack under the strong heating effect and thus lose their protective qualities.

Telescope

We differentiate between 2 types:

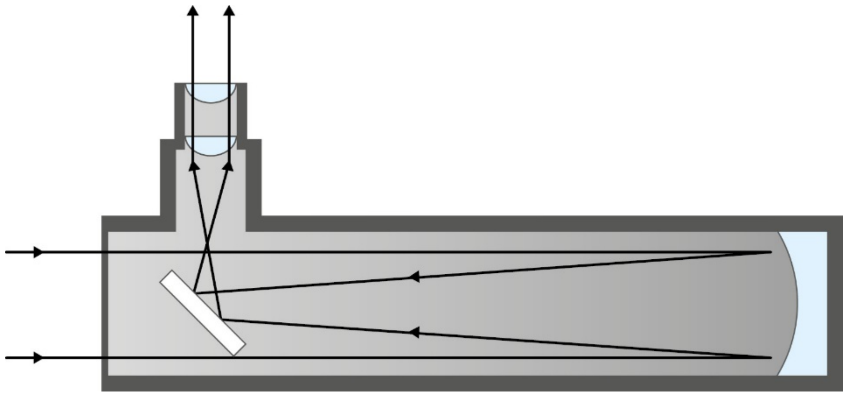
Lens telescope = refractor

A refractor is always more expensive than the same diameter mirror since the manufacture of lenses is more complex than that of mirrors. Lenses of 100mm and larger must be manufactured extremely carefully. Refractors have a higher image definition (higher image sharpness and high contrast). The view path is usually linear.



Reflector telescope = reflector

Reflectors are cheaper due to their mirror, which can be manufactured with less effort, and for the most part also have a higher light intensity due to their larger diameter. Commercially available reflectors are constructed according to the system that was already used by Newton. Another advantage of the reflector telescope is that there is no chromatic aberration. The view path is 90° lateral to the tube.



Erecting lens/erecting prism

Astro telescopes generally show an upside-down image. Use an erecting lens/erecting prism for terrestrial observation.
These optical accessories are inserted between the eyepiece and the telescope.

Magnification

Magnification is not only defined as the ratio of the focal length of the objective to the focal length of the eyepiece of the telescope, it is also defined as the ratio of the entrance pupil to the exit pupil of the optical system, which also includes the observer's eye. The size of the eye pupil is to be regarded as the exit pupil if that the exit pupil of the eyepiece used is larger. The minimum magnification is therefore determined by the size of the pupil of the eye and the aperture of the telescope lens.
With increasing age, the lowest magnification possible increases due to the increasingly smaller eye pupil (see chapter on exit pupil).

The following calculation should explain this. Assume the data of a 4 ½ inch (114 mm mirror), then you get a minimum magnification

$$V_m = \frac{\text{Entrance pupil}}{\text{Exit pupil}} = \frac{114}{8} = \text{approx. 14 times}$$

Up to the age of 40, this is also the minimum enlargement to be expected. After that, the minimum magnification increases steadily and at the age of 70 the value has doubled, namely to $V_m = 38$.
Using a lower magnification than V_m can be very useful for expanding the field of view when searching.
Which eyepiece corresponds to the minimum magnification?

$$\text{Eyepiece focal length} = \frac{\text{Telescope focal length}}{\text{Minimum magnification}} = \frac{900\text{ mm}}{14\text{ mm}} = < 64\text{ mm}$$

You should choose eyepieces with a focal length smaller than 64mm.

To determine the maximum magnification, it is important to know that the exit pupil (eye) does not drop below 1 mm, as the retina cannot resolve any finer than this. In the formula for the minimum magnification, enter 1 mm instead of 6 mm for the pupil of the eye: then you get the size of the mirror diameter as the maximum magnification V_h. The eyepiece focal length resulting from this is approx. 8mm.

A shorter focal length of the eyepiece only apparently provides greater magnification, although no further details can be seen. This is known by specialists as "dead" or "empty enlargements". Thus, you should only acquire eyepieces that are between the focal lengths for the minimum and maximum magnification.

USEFUL OBSERVATION ADVICE

The first observations using the telescope

After setting up the telescope you can start observing immediately, although the observation results will not be optimal. The telescope parts only adapt to the outside temperature after about half an hour. Otherwise, the image quality would be poorer due to air streaks inside the tube.

When trying to find an object with the telescope, first aim with the finder scope and centre the object on the crosshairs. **An exception to this is observation of the sun: the finder scope must not be used to find this object under any circumstances, otherwise there is the risk of incurring irreparable damage to the eyes!** For this reason, it is best to remove the finder scope.

Then the eyepiece with the longest focal length is inserted into the focuser, so that the field of view is large and you can find the object you are looking for more easily. You can then fall back on eyepieces with a shorter focal length in order to achieve a higher magnification.

The maximum magnification with which you can still obtain a good image is roughly twice the mirror diameter. If you have a mirror with an aperture of 114 mm, the theoretical maximum acceptable magnification is approx. 220 times, although this would not necessarily be useful. The telescope has the best image quality when the magnification is equivalent to the mirror diameter (114x in our example). The magnification can be calculated very easily by dividing the telescope focal length by the eyepiece focal length:

$$\frac{\text{f telescope}}{\text{f eyepiece}} = V \qquad \textit{Example:} \quad \frac{900}{6} = 150$$

Of course, the telescope can also be used for terrestrial observation. Please note, however, that the image in the eyepiece is upside down. An erecting prism or an erecting lens (optionally available) is required to render the image upright.

After the optical properties of the telescope such as diameter/aperture and focal length, two other factors also play an important role in astronomical observation: the mounting (see chapter on Mounting) and, to a large extent, the prevailing weather, light and environmental conditions. In a dark place on a clear winter's night there is infinitely more to see than in a "light and environmentally polluted" city.

WHAT YOU CAN OBSERVE WITH THE TELESCOPE

The sun

ATTENTION!
We strongly recommend that observations of the sun should only be carried out by trained and experienced users and never without adequate eye protection. This applies to both the telescope and the finder scope. The best thing to do is to remove the finder scope from the tube; it is not required for solar observation. There is a risk of irreversible damage to the retina in the eye and even blindness!

To safely observe the sun, we recommend a **special sun filter** which absorbs 99.99% of the sunlight. We carry this film in A4 format. You create your own cardboard holder to fit your lens. You put this filter attachment in front of the lens and can thus observe safely.

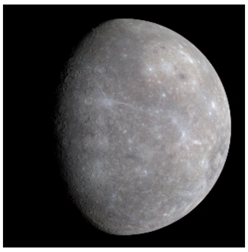
ATTENTION!
Eyepiece filters for solar observation are not recommended due to the health risk. Due to the marked heat buildup, these can burst and the sunlight hits the eye unfiltered – risk of blindness!

The moon

The moon is one of the most gratifying objects in the firmament. Especially when the moon is waxing or waning, the craters on the line dividing the moon (the so-called terminator) appear particularly three-dimensional. A lunar eclipse can also be observed very well. You can observe how the shadow of the earth slowly sweeps over the moon and gradually covers individual craters. If it is viewed under a full moon, the excessively bright light can be perceived as annoying. For this reason, most telescopes come with a moon filter. You simply screw this into the eyepiece sleeve and then you have a darker image. The filter also increases the contrast.

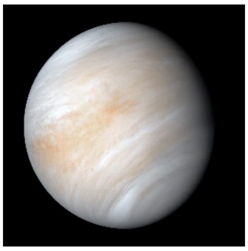
ATTENTION!
Under no circumstances should the filter be used to observe the sun – the moon filter could burst and the unfiltered sunlight hit the eye: risk of blindness !

The planets



Mercury

Since Mercury's orbit is very close to the sun, it can only be observed shortly after sunset or just before sunrise. It then appears as a cream-coloured half-sickle or sickle. Details cannot be seen on its surface.

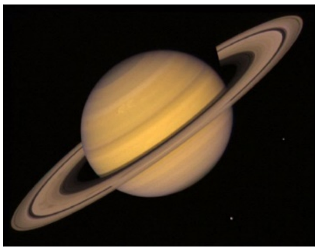


Venus

Is surrounded by thick cloud cover. Thus, no surface details can be seen. The different phases of Venus can be observed very well (and are similar to the moon). The sometimes very bright planet cannot be missed as an evening or morning star.

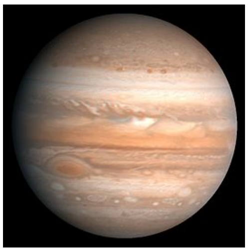
Mars

Mars appears as an orange disc in the telescope. With a little practice and patience, you can see the polar ice caps on the surface, as well as lighter and darker spots and stripes. If you observe it over a longer period of time you can see changes in the size of the polar caps.



Saturn

The most interesting thing about Saturn is its ring system. For example, you can see how the inclination of the ring changes over the years. On closer inspection, it is noticeable that the ring is divided into two parts. This "gap" is known as the Cassini division. In the best case, four Saturn moons can also be seen.



Jupiter

Jupiter is always a worthwhile object in the firmament. It is rich in details, such as the four Galilean moons Io, Europa, Ganymede and Callisto. Their movement around Jupiter can be followed, as can the passage of a moon in front of the Jupiter disk. Eclipses of the moons by Jupiter and moon shadows on Jupiter's surface are no longer hidden from you. You can also see the different thick bands of clouds on Jupiter and even the well-known large, red spot on the surface, which represents a huge cyclone system.

Uranus, Neptune and Pluto

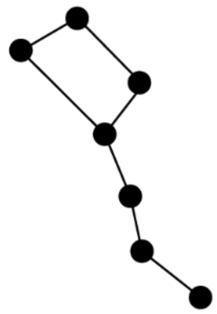
These are not worthwhile observation objects. Firstly, they are very difficult to find because of their low brightness and secondly, no further details can be seen through the telescope.

Looking for planets and other celestial objects

To find the planets better, you can consult the monthly star maps in your daily newspaper. It is better to purchase a star map, yearbook or star atlas from your specialist bookshop (list of literature at the end of the instruction manual). You will also find other interesting celestial objects in these books or maps, a few of which are described below.

Observation of fixed stars

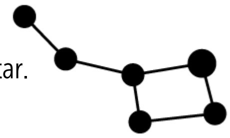
In Spring



The Great Bear or Plough/Big Dipper constellation

This contains the well-known double star pair Alkor and Mizar, which can be distinguished by naked eye. Through the telescope, Mizar appears as another double star.

Pole Star and Ursa Minor (Little Dipper)



Through the telescope, the North Star appears as a double star with a very faint companion star.

Leo

The main star Regulus is a binary star system, as is the tail star Denebola. In the middle of the Denebola-Regulus line is the spiral nebula M96. Through the telescope it appears to be rounded-oval.

Virgo and Coma Berenices

Gamma is a beautiful double star in this constellation, with two equally bright components. The spiral nebula M100 is also interesting. Through the telescope it appears as a blurred secondary spot. M53 is an open cluster with about 50 recognisable stars by telescope.

In Summer

Hercules

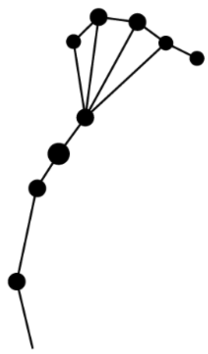
In Hercules, the two globular clusters M13 and M92 are worthy of note. These form a bright, round area in which many stars are hidden.

Lyra

This contains ring nebula M57. The shape of the ring is clearly visible by telescope. Lyra is also home to a beautiful binary star system, namely the star Epsilon. If you can still see two stars with the naked eye or through binoculars, then four closely spaced stars suddenly appear in the telescope.

Cygnus the Swan

The swan's head star, called Albireo, is a beautiful double star system, each of the two stars being distinctly different in colour. One is bluish and the other is orange. Also worth mentioning is the star cluster M39, near the star Deneb.



Scorpio

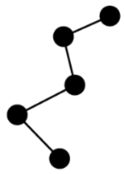
Scorpio holds a wealth of objects to be observed by telescope. At this point only the star clusters M4, M6 and M7 should be mentioned.

Protection

A telescope tour through Sagittarius with the interesting globular clusters M22 and M55 is just as rewarding. The two gas nebulae M17 (Omega nebula) and M20 (Trifid nebula) are also easy to find.

In Autumn

Cassiopeia and Perseus



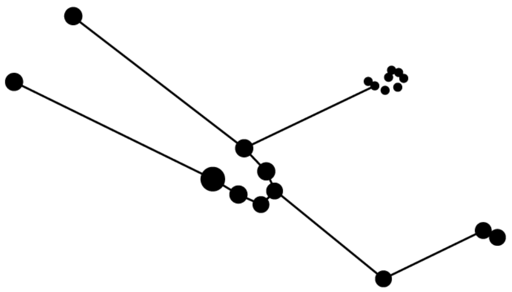
The open star cluster h and chi lies between these two. At low magnification it unfolds its full splendour. One of the most famous variable stars can be seen in Perseus: Algol. Its brightness fluctuates by a good one-and-a-half magnitudes within three days. With a trained eye, a change in brightness can be observed during the night.

Andromeda

This is home to the most famous galaxy in the starry sky: the Andromeda galaxy. It is impressive even without aids, although it only unfolds its full beauty under the telescope. You can see an elongated nebula with a light core. The binary star system Gamma Andromeda is also worth a look.

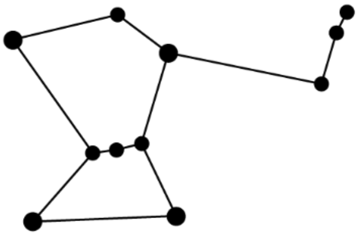
In Winter

Taurus and Orion



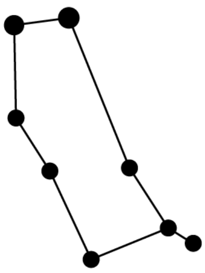
There are two open star clusters in this region of the sky. The Pleiades and the Hyades. Both can be seen with the naked eye. It is advisable to use only a low magnification, otherwise the star clusters lose their splendour. At the Pleiades you can then recognize the 80 stars, which offer a wonderful sight. M36, M37, and M38 form almost a straight line in Auriga. Each of these star clusters is worth taking a closer look at.

Orion



The Orion nebula under the belt stars is noteworthy. Trapezium is visible within this nebula. These are four stars that are very close together. Rigel forms a complex double system, whose companion is very faint.

Gemini



The double star Castor and the open star cluster M35 should be mentioned here.

Note

When the moon is full, the observation of many celestial objects is severely hindered by the diffuse light of the moon. Find an observation location that is as dark as possible outside the interference of city light.

TIP

If you observe at night and want to use star charts for orientation, use an infrared torch (optionally available from DÖRR). Due to the bright white light of conventional torches, visual adaptation is lost and you can see fewer details. Infrared light does not affect this adaptation.

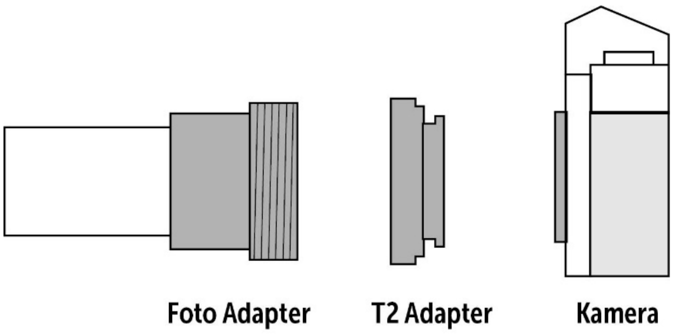
INTERESTING FACTS ABOUT ASTRO PHOTOGRAPHY

Modern technology offers the amateur and star enthusiast the possibility of photographically capturing interesting and extremely varied objects in the night sky, such as star clusters, coloured nebulae, galaxies, etc.
The only requirement for your own camera is that its shutter allows long exposure times and that it has a high light intensity lens (f = 1: 3.5 or better). This is possible with SLR and system cameras.

There are several ways to carry out celestial photography. The specialist literature provides detailed information on this.
We will go into more detail below on what is known as focal photography.

Focal photography

The lens or the mirror of a telescope are used directly as a camera lens. Instead of an eyepiece, the camera is attached to the telescope focuser using a suitable adapter that contains its own lens system. However, with a mirror focal length of 1000 mm or more (which corresponds to a powerful telephoto lens) only small areas of the sky can be photographed. However, compared to the images from section 1, these are enlarged according to the mirror focal length **(example: in 1. Lens focal length used f_K = 50 mm, mirror focal length f_T = 1000 mm, magnification factor f_T/f_K = 20)** and therefore more detailed. However, exposure times have to be considerably longer due to the much lower light intensity. The prerequisites for this are precise polar axis alignment, precise tracking and high mechanical stability of the entire apparatus. Astro photographers should thus not try focal photography when starting out.



Further Literature

The book trade carries a range of good quality literature that is easy to understand, as well as star maps and manuals. A number of astronomical magazines are published in German and English that contain regular articles on astronomy. Publications of easily understandable summaries of complex topics relating to astronomy and cosmology are also available in special editions.
For advanced amateurs, tables are offered for observation, some in calendar form.

DÖRR also sells astro-literature and star maps from Kosmos-Verlag through its partner dealers. For more information, contact your dealer or DÖRR, Neu-Ulm. No special recommendations are made here, the market also changes very quickly, so a list would not be very helpful or exhaustive. The astronomical associations in your area can also advise you.

11/2020