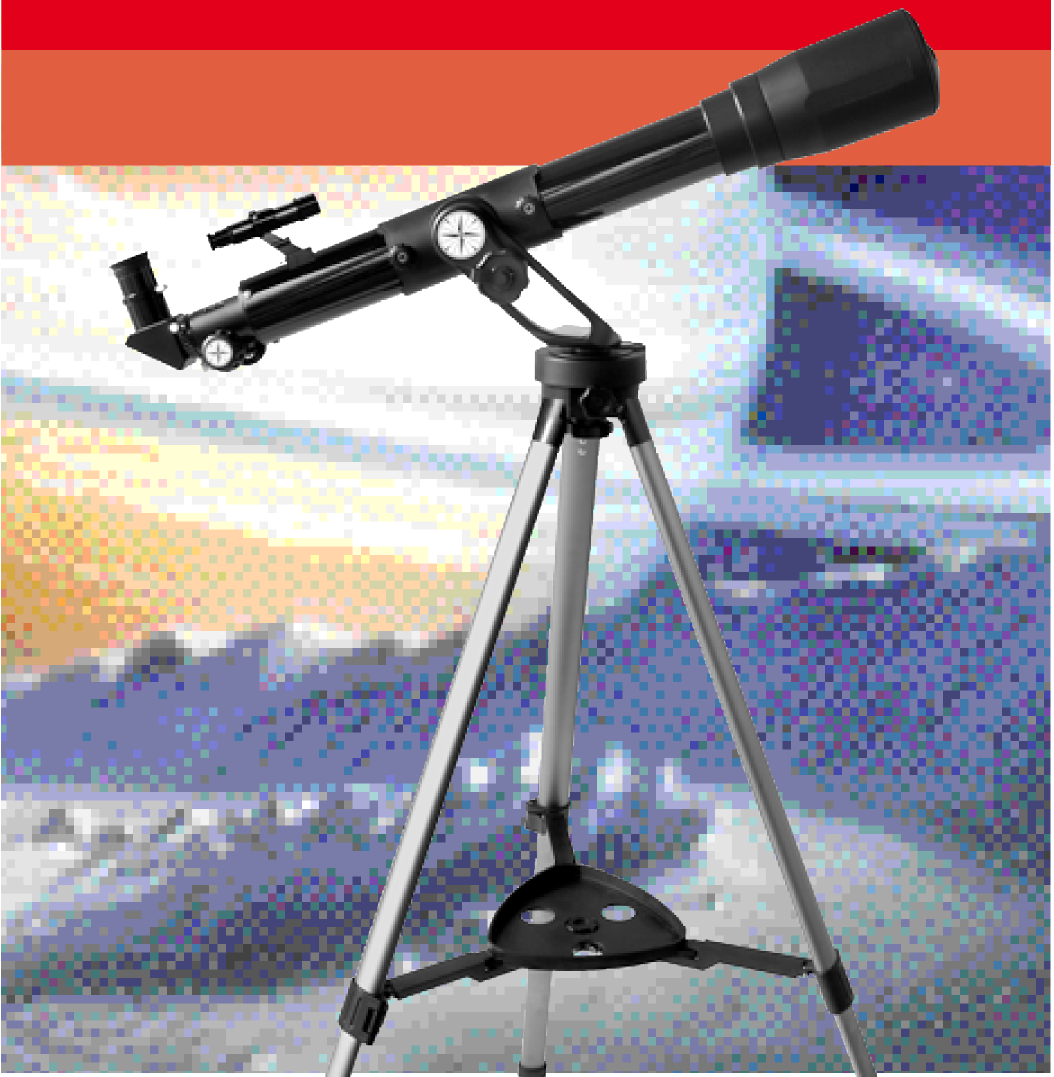
Astronomy brochure



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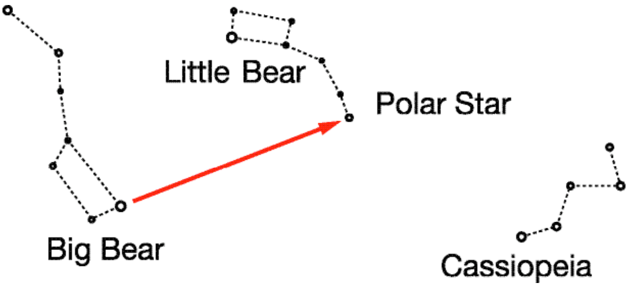

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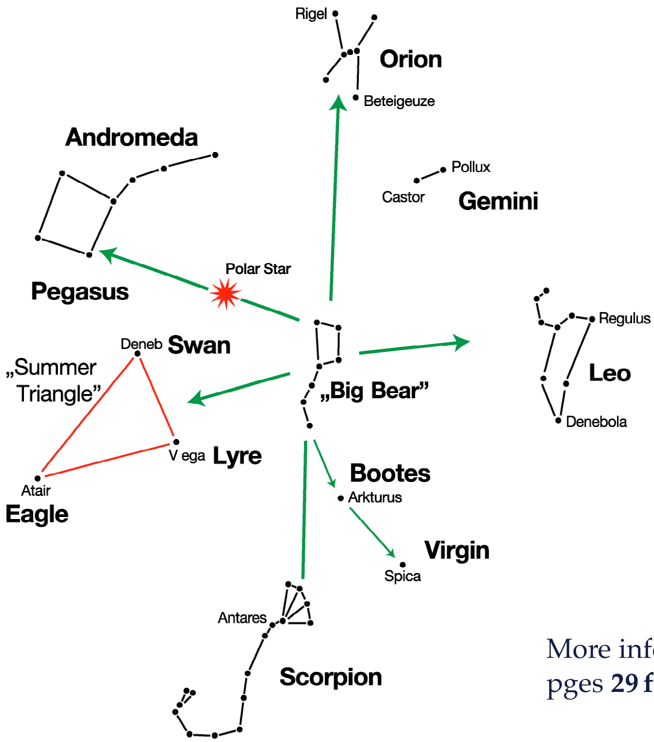

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1. Introduction

Since primaeval times, human beings have been interested in the celestial objects. For many thousands of years humans identified figures in particular groups of stars, which we today know as constellations.

Before the discovery and development of optical visual aids (Spotting scopes, telescopes) one could only look at the sky with one's own eyes. Therefore people only had an overview of thousands of stars. With the development of astronomical telescopes humans could see further and further into space. Thus the foundation-stone was laid for scientifically-based astronomy.

The further mankind looked into the universe, the more stars, galaxies, nebulae, star clusters and star systems became visible. They produced new mysteries about the emergence of the universe and of our earth.

Astronomy is an "infinite history "and that makes it also interesting for the layman..

1.1 The fascinating universe

If you come across text printed in blue, then this term is explained, together with many other technical words, in the Glossary starting on Page 56.

As a brand new owner of a telescope we would naturally like to immediately penetrate into the depths of the universe. Star observation can only take place on clear nights. If the weather is not kind to us, then we have more time to prepare ourselves for the first night. It is sensible to set up the equipment during daylight, which must eventually also be carried out in the dark. This telescope booklet is here to help you to obtain your first view of astronomy.

When finally, after a long wait, the sky clears and produces a clear view of the starlit skies, then it is time, to give " first light" to the telescope, as amateur astronomers call „the baptism "of the telescope into the free sky. These evenings can be crucial in determining whether one is struck with fascination for the starlit sky or whether one is put off the hobby by the grind and disappointment of breakdowns. In the age of space travel, we are spoiled by astronomical photographs, taken up space probes and large telescopes. Science fiction films on television and in the cinema impress us with breath-taking star worlds. Our level of expectation regarding our telescope is consequently high. The first view through our telescope may therefore be somewhat sobering. With time we will find that the observation of astronomical objects experienced with our own eyes can be an exciting and fascinating passion. In order to ensure that the telescope does not become a poor investment, as a telescope manufacturer we have written a short manual, to introduce you a little to this fascinating hobby. We do not wish to pass on complex science, but to give a short, practical guide, on how to handle a telescope and what can be observed.

1.2 History of astronomy

Although the science of astronomy has developed over the last 4000 years, we can assume that mankind has been interested in the celestial objects and with the structure of the universe from the beginning of its existence several hundred thousand years ago.

From the ritualistic actions of the first thousands of years, today's astronomy has developed over time, into the science that we know it today.

At first humans built simple, but ever more perfect and precise devices, to observe the movements of the sun, the moon, the planets and the stars.

Knowledge, gained by the ancient Egyptians, Greeks, Babylonians, Mayas and the Chinese at that time using quite primitive means, still astonish us to this very day. For example was Stonehenge in Salisbury in Southern England an astronomical calendar and cult site of the Celtic druids? How is it that the location of the pyramids of Giza in Egypt almost perfectly portray the constellation of Orion? How did the Mayas manage to pre-calculate a solar eclipse? How did people use astronomy in agriculture, religion and politics? All fascinating questions, which even today have not lost their attraction.

The age of modern astronomy began when Galileo Galilei in 1604 directed a tiny lens telescope against the sky and, full of fascination and curiosity, made the first observations.

The invention of the telescope brought new surprises. It was discovered that the Milky Way, that weakly shining band, which stretches itself across the whole sky, consists of millions and millions of stars.

Small, bright marks in the sky were identified as galaxies and similarly our Milky Way System, in which our sun is only one star amongst an almost infinite number of stars. As the light collecting ability of the telescopes increased, all the more stars and nebulae were discovered. The universe was many thousand times larger than the astronomers of antiquity had ever imagined.

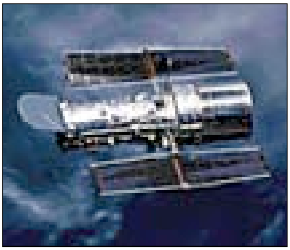


Fig 1:The "Hubble" telescope in Orbit around the Earth. Photo: NASA & STSel

Since the employment of modern space-travel technology and the various new instrumental possibilities, astronomy has made an enormous leap forward. The knowledge of astronomy in 1990 is probably about three times as great as it was in 1950. If one considers that all generations of astronomers from the oldest cultures of China, Egypt, Central and South America, Greece etc, all together did not produce more than the astronomers of the last three decades! This also applies when taking into account the reformers of astronomy at the beginning of modern times such as Copernicus, Kepler, Galileo or Newton right up to the first observers of the large telescopes on Mount Wilson or Mount Palomar in the first half of the 20th Century.

In 1990 the first astronomical telescope, named "The Hubble Space Telescope" was positioned in space. Thus a new chapter in the infinite history of astronomy was surely opened.

Fig: 2: The large ringed plant Saturn photographed by Hubble. Photo: NASA & STSel

During the course of the nineties, most diverse satellites and probes were associated with Hubble, using different methods to explore our solar system and the depths of the universe.

In 1999 the ESO put the "Very Large Telescope" (VLT) into operation in the Atacama Desert in Chile. This equipment is one of the world's largest optical telescopes and consists of four individual telescopes each with a diameter 8.2m . These ultra-modern instruments are supplemented by three small, mobile telescopes with each 1.8m in diameter. With this unequalled optical solution and under perfect weather conditions, the VLT produces extremely sharp pictures and picks up light from the smallest and most distant objects. These activities even exceed the Hubble space telescope.

2. The view of the starlit sky

What I see, I believe…
To our eyes the earth appears as a disk, over which is inverted the sky hemisphere. The earth is however in reality a small, round planet. The sky is not a hemisphere, as accepted in earlier times, but surrounds the earth on all sides. In one period of approximately 24 hours the earth rotates once around its axis. The continents lying on the surface of our planet are turned to face the sun for part of this period, for the remainder they are turned away from the sun. For us human beings this results in the change between day and night results. If one observes the sky on a clear night over a period of time, then one sees that the stars do not stand still. They rise up in the east and set again in the west. In earlier time humans concluded from the fact that the visible vault of the heavens formed itself into a hollow ball beneath the earth disk, from which the celestial objects rise and set again.

As the stars, with some exceptions, do not change their position and the brightness relative to each other one, it was thought that the stars were fixed to this ball and therefore gave them the Latin name: stellae fixae).

How large the sky ball was nobody could determine but it was considered to be immeasurably large. Humans imagined themselves to be always exactly in the centre of the ball, regardless of, at the exact place they were on earth.

… and nevertheless it rotates
It took centuries before people recognized the fact that the stars do not rotate around the earth – but that the earth itself rotates in space around its polar axis.

The stars seem to move in the sky, because the earth rotates around its own axis. This rotation causes certain parts of the heavens to become visible to the observer every 24 hours. (24 hrs: the earth needs 24 hrs for one complete revolution).

By day it can be seen that, due to the earth's rotation, the sun appears to rise in the eastern horizon, stays in the sky for some hours and then again apparently goes down below the western horizon. At night one sees the apparent movement of the stars. There is not just the sun rise and sunset. There is exactly the same for the rising and setting of the moon and also for the stars and planets we speak of rising and setting. That naturally applies to all celestial objects.

There is a choice of different optical instruments
If we start today on the road to observing the heavens, then two questions arise: "What do I want to see? " and "How detailed will I see it?". There are different possibilities for observing the stars. One can undertake the observation with the naked eye and for example explore constellations or shooting stars, or pick up a pair of binoculars and explore the constellations and the planets. To see the objects more closely and to explore planets, comets and galaxies, you need a proper, large telescope. If however you wish to observe the land as well as the starlit sky you can still reach for your binoculars or Spotting scope. Lens telescopes are also suitable with special accessories for land observation.

2.1 Observing with the naked eye

If you are out and about during the evening, and look at the sky with the naked eye, then even as a lay person you will already recognise some remarkable celestial objects. Depending upon how darkly it really is, that is to say how strongly the night is "polluted" by city light, you can also notice one or more weakly shining object. If the moon is to be seen, this would naturally be the first to catch the eye. It can frequently even be seen by day or in the early evening before sunset. The moon is the nearest object to us. However if the moon is not to be seen and the skies are crystal clear, one can still clearly identify many other objects. The band within our own galaxy, the Milky Way, is quite easy to recognize. Depending upon the time of year and the time of day the bright star Sirius as well as the planets Venus, Jupiter, Mars and Saturn can be identified. The constellations take up the largest area of the heavens and some constellations which can be recognized very easily can be made out in the sky almost immediately. The interested layman can immediately recognizes one or other of the large conspicuous constellations such as the Great Bear or Orion.

Fig 3: A complete, assembled spotting scope.

2.1.1 Observing constellations with the naked eye

The arrangement of the stars in the heavens, spurred the mankind imagination of humans in antiquity to combine the arrangements of stars into pictures. Thus fallen warriors wandered symbolically across the heavens and monsters from the underworld fought with heroes. The signs of the Zodiac also developed in this mythical way. For example the mythological background of Orion is particularly interesting: the warrior hunted the Pleiades, the seven daughters of Atlas. Arthemis sent the scorpion to kill Orion, which it did. Thus Orion sets in the west when his murderer, the scorpion, rises in the east.

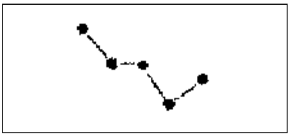


Fig 4: The constellation of Cassiopeia.(In mythology the mother of Andromeda)

Orion, the great bear, the little bear or the W-in the sky (Cassiopeia) are clearly recognisable constellations, which can be quickly found. Orion, for example, is a constellation, which is visible throughout the whole of winter. The constellation seems to give the appearance of an inclined hour glass. The three stars forming the belt of the mythological hunter Orion are the easiest to identify, as he fights in the night sky against the bull (lat. Taurus). One can also soon recognise the stars forming the shoulder, head and foot of Orion.

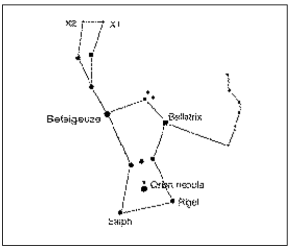


Fig 5: The constellation of Orion. (In mythology the hunter of the Pleiades)

The great bear is clearly visible for virtually the whole year and is an easily recognizable constellation. It actually looks like a hand cart, a trapezoidal body and a handle. This constellation is a part of the Great Bear.

Observing shooting stars with the naked eye

They were pointed out to us as children, in order to wish for something. They are clearly visible with the naked eye and occur whenever small particles from space enter the earth's atmosphere and glow due to friction. They can be rock dust, which can vary in size between 2mm and 30cm and above.

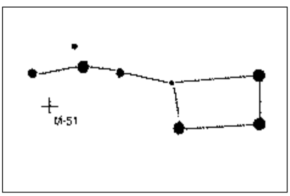


Fig 6: The constellation of the Great Bear. (Also the known as the Plough)

2.2 Observing with binoculars

With good binoculars many things can be discovered in the sky. Binoculars can be fitted onto a stand using a stative thread. If it is possible to identify several thousand objects just with the naked eye, then it appears that more objects will be found with the binoculars. It is not the increase in the number which makes the difference however, but rather the possibility of magnifying the objects. With good binoculars you are in a position to identify the moons of the planet Jupiter. Take aim at the constellation of Orion, below the stars forming the belt the Orion Nebula M 42 can be observed. This comprises an enormous cloud of inconceivable extent, which consists of cosmic dust and gases and becomes illuminated by UV light shining from the stars.

Fig 7: Binoculars of the Porro type

Our neighbouring galaxy M 31 (fig. 8) can also be recognised as easily with binoculars. No wonder, it extends across the heavens for over five moon diameters. It is a beautiful spiral galaxy of a similar to our own galaxy (the Milky Way).

2.2.1 Observing planets and moons with binoculars

If you see a bright "star" in the sky, which is not shown on a star map, then it is for certain a planet. The earth is one of nine planets, which all circle the sun. Two of the planets, Mercury and Venus, are closer to the sun than to our Earth. The other planets Mars, Jupiter, Saturn, Venus, Neptune, Uranus and Pluto are further from the sun than our earth.

Five of the planets - Mercury, Venus, Mars, Jupiter and Saturn – can be recognized easily with the naked eye or binoculars. They appear to us like bright stars, until one observes them with binoculars or a telescope. Detailed observations are not however possible with binoculars due to the low magnification.

2.2.2 Observing deep sky objects with binoculars

If one leafs through astronomical technical periodicals or through advertising brochures of some telescope dealers, then one inevitably discovers the term "DEEP SKY". Astronomers call all objects, which are beyond our planetary system, deep sky objects. That is a whole pack of objects of interest, which will open itself to our eyes, when we go on safari equipped with binoculars or telescopes. As we have already mentioned in the introduction, we are spoiled with multicoloured pictures of bright gas nebula, from the media and advertisements. If a layman hopes to be able to see this colourful display in the binoculars he will be somewhat disappointed at the beginning. The pictures are photographic images requiring long exposure times, which cannot be seen by eye even with the largest telescopes. Naturally one should not be disappointed, because one can still see very much more with binoculars, than with the naked eye. For instance, the eye has a maximum pupil aperture of 8mm. With binoculars with only 50mm aperture the surface, which collects the light, is already large enough for one to still see stars that are 7 times darker, than the faintest stars which can be recognized with the naked eye. This opens up a large selection of interesting objects.

Fig 8: Our neighbouring galaxy. Andromeda – "Nebula"

The larger the lens aperture, the more stars are recognizable. But even large apertures are not able to arrange colour images for us. Our brain, which processes the pictures of the retina, has a maximum "exposure time" of a quarter of a second, to compare this time with a photo camera. In order to photograph gas nebulas or galaxies, the cameras on large telescopes are often exposed for several hours. For visual observers at night all cats remain grey.

If one wants to observe double stars and star clusters, here visual observation is usually superior to photography. Beautiful images, which leave sparkling accumulations of stars with the observer, are not reproducible on photographic paper. Here one can savour the astronomic experience in full measure.

In order to come to fully appreciate deep sky objects, one needs as clear and dark night as possible. The astronomer's enemy here is not only the weather, but often also the moon, which lightens the sky. Clear new moon nights are very well suited, preferably out in the country, remote from civilization. There light contamination due to cities is smallest.

2.2.3 Every beginning is easy

With deep sky observation, finding your way about the night sky is important. In antiquity the astronomers formed the prominent stars into constellations, which were shaped and given a name, using considerable imagination. The constellations in the northern sky are entirely formed by figures from Greek mythology. If one compares the sky with a globe, then one can compare the constellations with the frontiers. Bright stars can be comparable to large cities. Visiting astronomical objects is possible by searching locally on maps. We use the prominent stars to assist with orientation.

2.3 Observing with the telescope

Telescopes come in many different versions, sizes and systems. For the beginner in astronomy it is often not easy to choose the correct model. An experienced astronomer once said: "Each telescope has its own sky"– and this sentence is to be only underlined. The focal length and/or the diameter of the objective/reflector of a telescope are not crucial – rather that the equipment is used within its optical limits. Basically it can be said that for the beginner a smaller and lighterRefractor (lens telescope) is most appropriate. Larger models are appropriate for the advanced amateur astronomer, since the structure and the handling presuppose some experience. However a small lens telescope and also a small reflecting telescope are both quickly set up in the garden and one can immediately start observing the sky. Compared to binoculars it is possible to observe moreobjects in the sky with the telescope. If thousands of objects could be seen with binoculars, then there are a hundred thousand celestial objects which could be seen through a telescope. In addition, it is not only the unbelievable number of objects that make a telescope interesting to use. The possibility of collecting a much larger quantity of light with the telescope, with allows selected objects to be observed in far greater detail demonstrates the variety in our universe.

Fig 9: A Newton reflector telescope

Thereare many different reasons for using a telescope. A lens telescope can even be used for land observations. A whole range of ideas for observation are offered, which can also be seen with binoculars: mountain ranges, the animal world, forest and game and even sporting events are possible. Similarly, with celestial objects many interesting goals are at our disposal. Beginning with our earth and the moon, then the planets of our solar system, up to the globular star clusters, planetary nebulae, gas clouds and galaxies in deep space, an almost inexhaustible variety is offered to us.

Fig 10: A lens telescope of the Fraunhofer refractor design

2.4 The moon

The moon is the largest and brightest object which we see in the night sky. It has a magnitude of – 12.5 mag. The moon with its craters apparently changes its shape, position and brightness from night to night and is therefore a very worthwhile object to observe. The moon does not radiate own light. It only reflects the light of the sun to the earth. It is the closest neighbour in the universe to the earth and is "only" 384,000Kms distantce away , it is about a quarter of the earth's size and developed somewhat later than the earth, i.e. approximately 3.9 billion years ago.

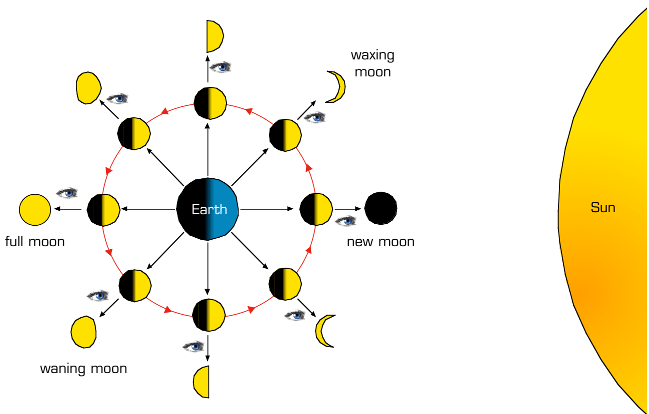
2.4.1 The phases of the moon

The moon orbits the earth. During the orbit different reflections of the sunlight are noticed on earth. The moon goes through these phases within 29 1/2 days. Daily papers or weather pages on the internet often publish the current phase of the moon. The individual phases of the moon are designated as follows:

- New moon (not visible)
- Waxing moon
- Full moon
- Waning moon

Since the moon rises and sets 52 minutes later each day, appropriate phases of the moon are visible at different times of the day and night. The invisible new moon is a day phase and the full moon can be seen throughout the whole night. The waxing phase can be best observed in the evening and the waning phase best after midnight.

Because of its independent movement, the moon travels much faster eastwards between the stars than the sun, so that it "overtakes" it at regular intervals. This period is called the synodic month and takes 29 days 12 hours 44 minutes. The moon's phases are the result of its faster movement.



2.4.2 The other side of the moon

If you observe the moon, you will soon realise that only one side of the moon is visible, because only one side of the moon is turned towards the earth. Until 1959 nobody had seen the far side of the moon – in that year a Russian, unmanned spacecraft orbited the moon and sent radio-photograms of the moon back to the earth.

2.4.3 The moon map

The moon map on page 12/13 shows the most important objects which are visible on the moon. In this map north is at the top - i.e. the moon appears to the observer exactly the same as it is seen with the naked eye or with binoculars.

With many telescopes the image appears standing "on its head" and inverted, then naturally the south is at the top. On many moon maps therefore the moon is shown as it is seen in such telescopes.

Many description of objects on the moon originate from Latin or English. On the moon map Latin names are shown since these are mainly used by astronomers.

To start with the large number of lunarobjects identified is confusing for the observer, but after a while you will certainly find your way about the moon. Why not go for a "moon walk"?

Close-up photographs of the lunar surface are also aids to observation. There are many books and even moon globes of various types and sizes which can also be bought in shops that specialise in such items.

In order to identify all existing moon objects, it is useful to observe the earth's satellite in all the moon phases. The objects on the bright/dark line (terminator) are particularly suitable for observing by means of the telescope or binoculars because this zone is very rich in contrasts. The light-dark line is not exactly straight, since it leads across many crates, mountains, valleys and seas. With a full moon observation is less satisfactory, because the sunlight radiates over all objects (no shadowing).

The greater the magnification of your telescope, the more objects you will be able to see on the lunar surface. Very good observations are also possible with good binoculars. Spotting scopes are also suitable for the observation of the moon.

2.4.4 Maria (lat. seas)

These dark areas are the special features of the moon. Together they result in "the face of the man in the moon". Former astronomers in ancient times believed that these were seas or oceans, but in reality they are flat areas of dark, volcanic rock. When the moon was formed they really were seas, seas of liquid lava.

2.4.5 Mare

(Plural lat. Maria) is the Latin name for seas. Some Maria are round, others have an irregular shape.

2.4.6 Craters

Circular depressions in the lunar surface are called craters. They often appear very deep to the observer– but in reality are not however. Craters are bor-

The picture shows the side of the moon visible from the earth with its most significant markings:

● = ***Maria (lat. Seas)***
Maria are large, dark areas on the lunar surface. They consist of gigantic primaeval craters, which in prehistoric times were filled with molten lava. Today the moon is completely cooled and does not have any molten layers any more.

● = ***Montes (lat. Mountains)***
These consists of mountain chains, which developed when the moon was still geologically active. They have been given the names of mountains on the earth (Alps, Appenines, Caucasus…).

● = ***Crater***
The many craters on the moons surface were created in the main from the origins of the Solar System. As the moon does not have an atmosphere, these are not weathered and remain intact.
The craters have been given the names of famous astronomers and scientists in accordance with international agreement.

● = ***Sinus (lat. Bays)***
These are parts of the Maria, partly also craters, which project from the edges of the seas.

▲ = ***Apollo Missions (USA)***
These are the landing sites of the American Apollo Missions during the 60's and 70's together with the mission number.

◗ = ***Unmanned NASA Probes (USA)***
These are the landing sites of the American Surveyor probes (in the 60's) with the mission number.

★ = ***Unmanned RAKA probes (Previously USSR)***
These are the landing sites of the Soviet lunar probes (60's and 70's) with the mission number.

For comparison: The curvature of the earth's surface
Mare Frigoris
Alpine Valley
Aristoteles
Lacus Somniorum
Posidonius
★ 17
★ 21
▲ 15
Caucasus Mts.
▲ 17
Mare Crisium
Mare Vaporum
★ 13
★ 23
★ 24
Mare Tranquillitatis
★ 20
★ 16
Sinus Medii
▲ 11
◗ 1
★ 9
◗ 3
◗ 6
◗ 7
▲ 16
Theophilus
Albategnius
Mare Nectaris
Fracastorius
Piccolomini
Stofler
Rheita Valley
Mare Australe
Leibnitz Mts.

dered by circular barriers and many have a small peak (central peak) in the centre. Some craters are circular, others on the sides of the moon appear oval - an optical illusion, caused by the spherical shape of the moon. The craters resulted from the impact of meteorites on the lunar surface.

2.4.7 Jet Craters

Jet craters can be seen very well with a full moon, because their surfaces consist of bright, reflective materials. They are produced by very violent impacts of large rock fragments. The jets extend with these craters over hundreds of kilometres on the lunar surface. The most remarkable jet crater is called Tycho (after the Danish astronomer Tycho Brahe, 1546 to 1601).

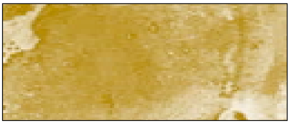


Fig 11: The smooth surfaces were really seas…of lava!

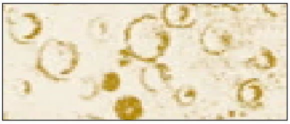


Fig 12: Our moon is scattered with craters.

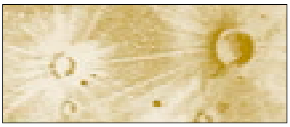


Fig 13: Violent jet craters on our moon.

2.5 Observing the planetary system with the telescope

For many thousands of years humans have observed the sky. They formed the bright stars into constellations and identified the regular appearance of the constellations in the annual rhythm. Celestial objects seemed to be firmly attached to the firmament and did not alter their positions relative to each other. There were other celestial objects, which altered their position within the constellations. One differentiated the planets from the fixed stars and stars which appeared to change their position. The planets always follow their own, self-willed paths through the signs of the Zodiac, in which also the sun and the moon move, however more or less chaotically, when viewed from the earth. The mystery of their paths was solved by Johannes Kepler (1571 to 1630), who set the sun at the centre of our solar system and did not make himself many friends at the time for saying so.

At first only five planets were known (Mercury, Venus, Mars, Jupiter and Saturn). Uranus, Neptune and Pluto were only discovered between the 18th and 20th centuries.

As an amateur astronomer you can observe nearly all the planets well, except Pluto, which is much too small and faint. Uranus and Neptune are visible, but mostly do not have any worthwhile objects for the telescope. These planets are too far from us.

If you see a bright "star" in the sky, which is not shown on a pure star map, then for sure it is a planet (Greek. Wanderer). The earth is one of nine planets, which draw their paths in the universe around the sun. Two of the planets, Mercury and Venus are nearer to the sun than our earth. The other planets Mars, Jupiter, Saturn, Venus, Neptune, Uranus and Pluto are further from the sun than our earth.

Pluto was discovered in 1930 by Clyde W. Tombaugh. Astronomers consider whether Pluto is really a planet, because it could also be a moon which has distanced itself from Neptune. Meanwhile numerous objects have been discovered at a similar distance from the sun, which to a large extent have much smaller diameters than Pluto, nevertheless however they possess very similar characteristics. One can therefore assume that there are still many planetoids, which have not yet been discovered.

Five of the planets - Mercury, Venus, Mars, Jupiter and Saturn – can be easily identified with the naked eye or binoculars. They appear to us at first like bright stars - as a pin prick - until they are observed with binoculars or a telescope. Then they appear as segments.

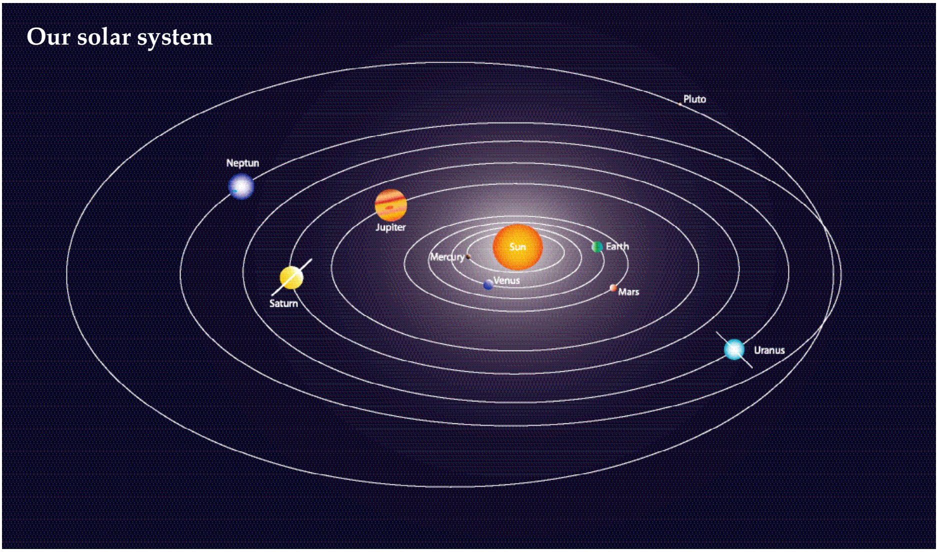


Fig 14: Schematic presentation of our Solar System.

In a telescope, a star always appears to us as a small bright point. A planet appears to our eye as a narrow illuminated disk, which with good visibilities appears spatial. If ever you identify a planet in the sky, then you will probably also be able to differentiate it, by eye, from the stars.

2.5.1 Where are the planets?

Planets are not shown on star maps, because they slowly but constantly "pass the stars by". If you observed a planet over several weeks, its path will become clear to you. One always finds planets in constellations of the signs of the Zodiac. They follow an imaginary line in the sky, which is called the ecliptic. The line of the ecliptic is shown on most star maps.

2.5.2 Observation of planets

Planets do not radiate their own light, but reflect light from the sun. The reflected light from the planets is very bright, so that they can to be observed in contaminated light in large cities and even with a full moon they are still quite recognisable are. It is however very difficult to make out details of the planet surfaces. The sky must be observed on a very clear night with a large telescope and then you will identify details on Mars or Jupiter. Around Saturn you will see the famous Saturn rings floating. It is nevertheless very interesting to observe the planets with binoculars or with the naked eye tracking their movements through the stars and to note changes in brightness over several days.

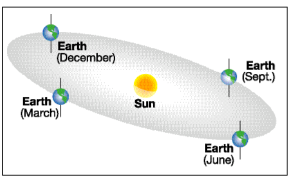


Fig 15: The path of the ecliptic

2.5.3 Position of the planets relative to the sun

Since the earth and the other planets move around the sun at differing distances from it, there position relative to each other constantly changes. Sometimes our earth is on the same side of the sun as another planet - another time the earth is on the opposite side to this planet. Astronomers have a name for these different positions. These are shown in the diagram in Fig. 16. Note that the markings for the inside and outside planets differ. With the changing positions of the planets the picture that we can see from

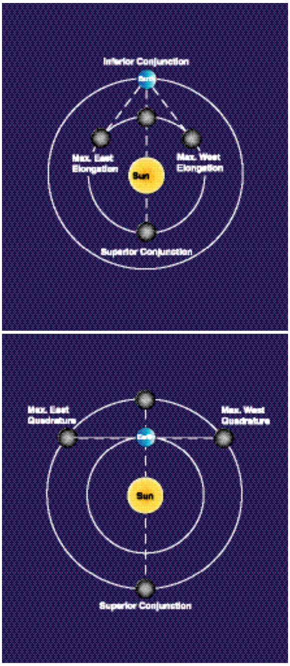


Fig 16: The position of the inner and outer planets.

the earth changes. For instance, the planets appear to us large and bright when they are close to the earth and / or small and inconspicuously, if they are far from the earth.

2.5.4 The planets introduce themselves

Here you will receive a short guided tour through our solar system. We begin our cosmic sightseeing tour with Mercury, the planet next to the sun.

Mercury, the rapid God messenger*

Mercury, the planet next to the sun is clearly visible in the telescope and is an interesting object, however, it does not come very often into the lens. The famous Copernicus (1473 to 1543) is supposed to have regretted on his death bed that he had never come face to face with Mercury. This fate should not happen to us.

Mercury rotates around the sun in only 88 days. It is only visible, if its angular distance to the sun is as large as possible. The maximum that Mercury can be from the sun is 27°. That means that Mercury can best be seen two hours before sunrise or two hours after sunset. Astronomers refer here to the largest eastern or western elongation. If Mercury can be seen by us, this is inferior conjunction, or if it is behind the sun and is not visible this is superior conjunction and it is not visible. Thus a good view of the horizon is indispensable, since Mercury must maintain ground against the bright evening light of the setting sun.

What can we see on Mercury however? During its path within our Earth's orbit around the sun, the phases of Mercury are as recognizable as those of the moon. If Mercury has the largest angular distance from the sun, then a half-lit planet segment can be seen. This is usually difficult to see, since it is usually in the brightest area of the dawn sky. Air turbulence within the area of the horizon makes the observation often generally speaking considerably more difficult, so that one can only observe Mercury's crescent with difficulty. One cannot identify surface details, although Mercury, beside Mars, is the only planet, whose surface is not wrapped in clouds. As photographs from space probes show, the surface is completely scattered with craters similar to those of our moon.

Venus, the bright beautiful one*

A more grateful object is Venus, which is known to us as the bright evening or morning star. Like Mercury, Venus also displays a crescent. Its orbit runs within the earth's orbit. The average distance to the sun is however twice as large as with Mercury at 108 million kilometres, so that the maximum angular distance to the sun is up to 47°. Venus can be observed four hours before or after sunset. It is substantially easier to find than Mercury because of its brightness.

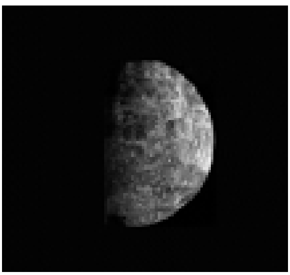


Fig 17: Mercury photographed from the US Mariner 10 space probe / NASA

On clear days it is visible even in the daytime sky. In the telescope Venus impressively displays its crescent to us. Surface details are not recognisable, since Venus is covered by a thick layer of cloud. With a 100mm telescope and high magnification it should be able to identify variations of the cloud cover. Colour filters, used by ambitious planet observers, will be helpful for this.

A completely rare event is the passage of Venus or Mercury across the sun's surface. Slowly the planet moves over the sun's disk and creates a mini solar eclipse. Even though other people may not be aware of it, it is a

Fig 18: Venus, photo taken from the US space probe Galileo / NASA

Fig 19: Rare event: The Venus passes by the Sun. This moment was captured by J. Ide.

high point among astronomical observations. Impressively one recognises the movement of the planet as a black disk in front of the sun.

NOTE! Very important. You must consider this!
During the observation of the sun the eyes must be protected against the sunlight by suitable sun filters. Directly viewing the sun through a telescope leads to immediate blindness which can not be reversed! Even with the naked eye, viewing the sun is very dangerous.

*** NOTE: Please remember when observing Mercury and Venus that these planets are a short distance from the sun. Ensure that you never search for these planets close to or into the sun. Immediate and permanent eye damage leading to blindness will be the consequence.**

Fig 20: Mars photographed by the Hubble space telescope / NASA

The red neighbour: Mars

Mars belongs without doubt to the most interesting astronomical objects. It is the only planet, which gives a view of its surface to our amateur telescopes. The most favourable time for Mars observations is when Mars is in opposition. That is, when the earth is exactly midway between Mars and sun. Then it is worthwhile to examine the Mars surface under the magnifying glass. Dark areas and the bright polar caps, which consist of frozen carbon dioxide, can be seen. The dark shades come from the different colours of the Mars soil, which consists of minerals containing iron. The thin Mars atmosphere and the high temperature differences between the day and night sides of the planet often lead to large sandstorms, which continually change the face of Mars. An amateur astronomer can already gain a small view of climatic conditions on Mars.

It is worth looking closely at the surface because many details can only be recognized after looking for a long time. The turbulent, terrestrial atmosphere is the enemy of the astronomer. With modern electronic picture recording procedures and the assistance of a computer, atmospheric disturbance can now be significantly reduced using amateur means.

Whilst observing Mars the distance between Mars and the earth plays a very large role. The distance between the earth and Mars varies very considerably. It varies between approx. 56 million and approx. 400 million Kms, depending upon the positions of the two planets. Therefore the diameter of Mars sometimes appears larger, sometimes smaller. On 28th August in 2003, the distance to the earth amounted to 56 million Kms. It therefore appeared particularly large. Observers of Mars had a looked forward to this event for a long time, because such an event only takes place every 1000 to 2000 years approximately.

Mars will show the observer many more details, as with the opposition in March 1997, which took place at the Mars aphelion. The planet was at the time about 100 millions km from the earth.

Note:
We used some technical terms which were not fully explained, during our little trip through the solar system. Therefore we have repeated our comments in summary in the glossary commencing on page 56.

Fig 21: Jupiter photographed from the Voyager 1 space probe / NASA

Jupiter and the dance of the moons

Now we come to the real "stars" amongst the planet, to Jupiter and Saturn. Once a year these two are in opposition and can be very easily observed a few weeks before or after opposition position.

Jupiter is a very bright, distinctive appearance, which is often erroneously interpreted by laymen as the morning or evening star. It takes nearly 12 years to complete its journey through the signs of the Zodiac. This means that each year opposition moves by one month. Despite its great distance from the earth, which in opposition amounts to over 600 million Kms, Jupiter reveals its planet segment shows us, which is 40 arc seconds in size. Jupiter is a gas planet and consists of hydrogen, helium, ammonia and further hydrogen compounds. It is covered in thick clouds. The atmosphere however has many characteristics. Like Jupiter it is surrounded by multi-coloured bands of cloud. The two main bands can readily be seen in the amateur telescope. After some minutes further bands

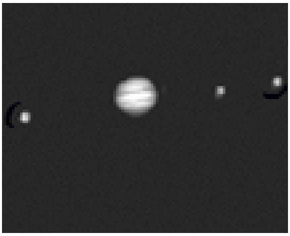


Abb. 22: Jupiter with three moons, photographed by a beginner's telescope

of cloud can be seen. Perhaps also the famous "Great Red Spot" can be identified. This is a hurricane which has continued for at least 300 years and is twice as large in diameter as the earth.

Because Jupiter takes approximately 10 hours to rotate about its own axis, the mark is not always visible, but only if it is on the day side and is turned towards us. The fast rotation of the planet leads also to a flattening at the poles, which gives Jupiter a slight egg shape.

The quality of the visual image depends on the prevailing air turbulence. Amateurs call the air quality due to turbulence seeing. With good seeing it should be possible to see a whole number of impressive details in a four inch (102mm) telescope, such as the main cloud bands and the great red spot, for example.

As previously suggested in the heading, Jupiter has still more to offer than the cloud formations on its surface. Galileo Galilei (1564 to 1642) discovered four small spots of light, which change their position around Jupiter.

The four moons, also referred to as the Galilean moons, can also be identified in very small telescopes and they are recognisable even in binoculars. This requires however a very steady hand or the use of a stand. The remaining moons, at least 50 in number, unfortunately remain hidden from us. The visible moons are IO, Callisto, Ganymede and Europa. The position of the moons to Jupiter constantly change and offer us each evening a different view. Often one can observe how a moon disappears in front of or behind the planetary disk. Due to the cloud cover on Jupiter's surface the moons often appear as small dark areas, which can be seen as black shadows on Jupiter's surface, presupposing good seeing however. One can find out the position of the moons in yearbooks, such as " Kosmos Himmelsjahr" (Cosmic Heavens Year). In these yearbooks all astronomical events for the current year are listed. They are consequently more than just an interesting reading for telescope owners.

The Lord of the Rings - Saturn

Saturn is the most impressive of the planets. Everyone has seen pictures of this ringed planet, but the live appearance of this planet is breath-taking. Observers experiencing this sight in the telescope cannot be removed from the telescope particularly during opposition, when Saturn shows an apparent planet of 20 arc seconds, then one can best observe the planet with its rings. In larger amateur telescopes, with good atmospheric conditions, separation of the rings into two can be seen. This is the Cassini division.

Abb. 23: Saturn, photographed out of the space probe Vojager 2/NASA

A further characteristic of the Saturn rings is the varying ring opening. Because of the slight inclination of the rings to the plane of the path of the earth, Saturn shows us the rings from all sides, in a cycle of approx. 30 years. In 1995 we were exactly at the level of the rings and Saturn seemed to be without rings. Afterwards the ring opening widened, so that the largest ring opening could be observed in the year 2002. During this time we saw the top side of the rings. Then for some years we could see the lower surface of the rings.

Like Jupiter, Saturn moons can be seen in the amateur telescope. The moon Titan is the most distinctive. In addition, the moons Rhea, Dione, Tethys, as well as Japetus can also be seen by amateurs. One knows the position

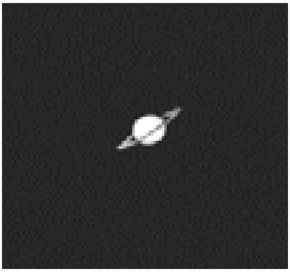


Fig. 24: Saturn photo taken with a beginner's telescope

Fig. 25: Uranus photo taken from the Voyageur 2 spacecraft / NASA

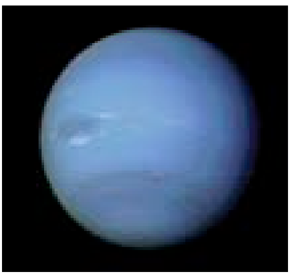


Fig. 26: Neptune. The image originates from the NSSDC / NASA databank.

of the moons from the yearbook " Kosmos Himmelsjahr" (Cosmic Heavens Year). In this yearbook all astronomical events are listed for the current year.

In the depths of our solar system

After Saturn follow Uranus and Neptune, then at the very edge of our solar system the planet Pluto.

Uranus can only be made out very weakly with the means available to us. This gas giant can only be seen as a tiny, greenish pin prick, which can easily be confused with a star. It is therefore advisable to work with a star map or planetarium software.

The planet Neptune is also a huge gas giant, covered with cloud formations exactly like Saturn and Uranus with their vapour trails. Neptune can only be observed with telescopes starting from 6 " opening (152mm). It is interesting with this planet that, like Jupiter, it exhibits enormous atmospheric turbulence, which cannot be identified using amateur telescopes.

Pluto, the outermost planet in our solar system cannot be observed with the telescopes usually available or with the naked eye. This small heavenly body consisting of ice and rock is more a planetoid (small planet) than a true planet and only has a diameter of 2,250Kms. Pluto is an ice-cold world, it has an atmosphere and dances on its path around the sun completely on its own (see fig. 12 on page 15). Pluto was discovered as planet in 1930 and is still called a planet today - even if it is probably not.

What else is happening?

After we have used the telescope to occupy ourselves with the sun and moon, with the planets and their characteristics, we might ask ourselves the question of what our solar system still has to offer.

Asteroids and small planets

In addition to the nine large planets there is still an immense number of small rock fragments in the solar system. Most of them are between the orbits of Mars and Jupiter. In the telescope these small objects are inconspicuous. Only 73 of the well-known small planets are accessible using small telescopes. In the yearbooks we often find only data for four of the largest of their kind: Ceres, Pallas, Vesta and Juno. Details of the surface are not recognizable with rocks less than 1000 Kms long. It is also not very easy to find small planets. If one nevertheless is able to seek out a small planet, one can observe its movement beautifully, relative to the fixed star sky. As a beginner one should not expose oneself to this test of patience yet, since this already presupposes a good knowledge of the heavens.

Comets

After the return of the Halley's comet in the year 1986 or the spectacular impact of the comet Shoemaker Levy 9 on Jupiter in July 1994 we were spoiled in 1996 and 1997 with particularly good comet appearances.

Hardly anyone could escape the media pageant surrounding the comets Hyakutake and Hale-Bopp.

Wonderfully we could identify the head and the beautiful tail of the two comets with the naked eye. Hale-Bopp, which acted as the century comet,

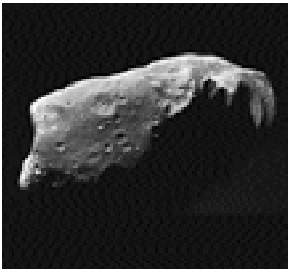


Fig 27: The Asteroid Ida, photo taken from the NASA space probe Galileo.

Fig 28: The Comet Hyakutake, taken by J. Newton.

Fig 29: The Comet Machholz, image taken by G. Strauch.

in the binoculars showed the slightly curved dust tail and the bluish ionic tail, which result from solar radiation of animated gas particles. In the telescope one witnessed enormous jets, emissions of gas and dust from the comet's nucleus, which supplied the material for the formation of the tail. For weeks the comet was brighter than the brightest stars in our sky. We cannot predict when we will again be able to witness such an event. Comets are unpredictable and are usually discovered coincidentally. No wonder that many amateurs hunt for comets themselves. Many comets are discovered by amateurs and then named after them. A challenge for the ambitious ones amongst us! Each year smaller comets, which are still visible in telescopes, are discovered. In addition there are also short period comets, which visit us once every couple of years. Their occurrence is usually inconspicuous, so that only a small, misty mark can be seen in the telescope. When searching for them the darkest skies are necessary.

Because of the unpredictability of the comets, one will find nothing in the yearbooks about the reSpotting scope positions of these objects. For current data one can fall back on technical periodicals or investigate the current data on the Internet.

Sources for comet data are for example the magazine "Sky and Telescope", NASA Web pages or web pages of the International Astronomical Union Circular:
http://cfa-www.harvard.edu/iau/Ephemerides/Comets/

Furthermore there are many private homepages, which concern themselves with this topic. Use an internet search engine and enter terms such as "astronomy" or "comet observation".

If these sources are not at your disposal, astronomical associations or observatories will gladly give you information. At the internet address www.astronomie.de/gad/ you will probably also find an observatory in your neighbourhood. Follow the instructions about comets with caution. The position indicators can be out by several arc minutes or the predicted brightness can be completely out. Comets are just incalculable. That is the special attraction of the search. Finding these challenging objects are small successful experiences and also help progress.

An important note:

Small planets are inconspicuous objects and many comets are unfortunately also very faint, so that with poor visibility they can hardly be seen, if not at all. As a beginner you should not try this search yet. Finally there is much more still to see and discover.

Fig 30: The open star cluster of the Pleides. Photographed by c. Kimball

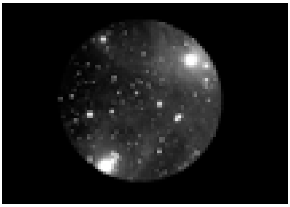


Fig 31: The Pleiades seen here through a 125 Superplössl lens.

Fig 32: The great Bear (also known as the Plough)

Fig 33: Planetarium Software simulates the whole heavens

2.5.5 Deep Sky observation with the telescope

If one leafs through astronomical technical periodicals or through telescope dealers advertising brochures, then inevitably you will find the expression Deep Sky. As a lay person man you will probably immediately think of the spaceship Enterprise or similar science fiction, however this is not like that, at all!

Deep Sky is about far galaxies, but we do not have to leave our native planet. Astronomers describe all objects, which are beyond our planetary system as Deep Sky objects. As previously mentioned in the introduction, we are spoiled by the media and advertising with multi-coloured pictures of bright gas nebulae and galaxies. If we hope to see this colourful scene in the telescope we will be very disappointed.

The pictures involve long-exposure, photographic images, which cannot be seen with the eye, even with large telescopes. Nevertheless, one can see more with a telescope, than with the naked eye. The eye has a maximum pupil aperture of 8mm. With a telescope with just a 50mm opening the light-collecting surface enables us to still see stars, which are seven times darker than the weakest stars, that could be to be seen only with the naked eye.

Let us now search for the double star Mizar and Alkor in the Great Bear.

Finding the seven stars of the Great Bear should not be too difficult for us. Which star however in the Great Bear is Mizar? A view of a star map will give us this information. The second star from the left in the handle is the double star Mizar/Alkor. Now let us try to lay on the pair of stars in the view finder of the telescope. With practice we will succeed and in the eyepiece we will see the beautiful double star Mizar and Alkor, which are popularly also called the "horse and rider". Success! We have found our first deep sky object in the telescope.

Unfortunately is not so easy to find everything, as Mizar and Alkor, but with perseverance and practice we will come to know the sky better and better. No master of the heavens has to fall out of the sky. For very little money there are aids such as star maps or yearbooks.

We will now go on a tour of the universe. First let us try to identify the constellations by means of the bright stars and go in search of beautiful astronomical deep sky objects. Before we start our tour, a few further words on the visibility of the constellations. Not every constellation can be seen at any time. The earth, on its journey around the sun, always presents us with a new view of the sky. Every day the constellations rise about four minutes earlier. During the course of the year the sky is continually moving towards the west. Only after a complete year is the previous state produced again and the constellations are positioned where they are at present. An example: If a star around midnight today is located exactly in the south, then tomorrow it will be there four minutes earlier. This circumstance means that we do not see the same sky in the summer, as in the winter. When planning a night's observations it is necessary to select the objects of the seasons accordingly. It does not make sense to look for the Orion nebula which is a winter object, in August. In chapter 2.7 "The most beautiful objects throughout the year" starting on page 29 a short guide, of what to see and when to see it, what is visible and worth observing and how to identify the correct object using star maps which can be rotated or so-called planetarium programs for computers.

Fig 34: M33 photographed with 8" Schmidt- Newton telescope and the Canon EOS 300D (Photo: R Maass)

Stars, star clusters, nebulae and galaxies

If one regards the nocturnal starlit sky sooner or later, faint, vague objects are noticeable to the observer. These are either gas nebulae, star clusters, the Milky Way or far off galaxies.

The brighter objects are usually recorded on the star maps –we will now present some of these here.

The Milky Way

The Milky Way, our homeland galaxy, is a spiral galaxy. It shows up as a resplendent band, which extends across the night sky. This comprises part of our star system. Our Milky Way looks from outside like a discus and has a diameter of 100,000 light-years and the thickness of 10,000 light-years (1 light-year is 9.46 trillion Kms). All stars move around the mass at the centre of the Milky Way. Our sun with its planets and moons, as well as hundreds of millions of other suns, moves on the journey around the galaxy nucleus. Far outside, on the edge of the galaxy is "the Milky Way". A view of the Milky Way with binoculars or a telescope shows millions of stars, which are closely crowded together. Our homeland galaxy consists of over two hundred billion stars and from the outside looks like an enormous spiral. You might possibly see the spiral galaxy M 31 which is very similar. Our small planet earth, within our solar system, is located on the edge of the Milky Way, in one of the spiral arms. It is represented in Fig 35 by a green point •.The red arrow indicates our line of sight, thus we always see a small section of the next to last spiral arm. All stars, which we can see in the Milky Way, belong to our galaxy. Even through the strongest telescope it is not possible to see through this collection of tightly-packed stars. Nobody knows, how the universe looks behind the Milky Way.

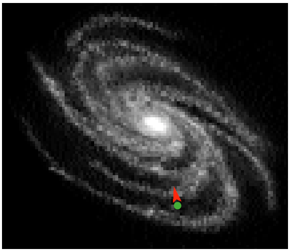


Fig 35: Illustration of our Milky way

Fig 36: The spiral galaxy in Andromeda (M31), a photo by J. Ware.

Fig 37: The Sombreo – Galaxy is also of the spiral-type and we can only view it from the side. This image belongs to J.Hoot.

Galaxies

Our galaxy (the Milky Way) is only one of innumerable galaxies, of which the universe consists. Some galaxies can be seen on a clear night from the earth, without optical aids. They look like faint spots of light in the sky, a conglomeration of millions of stars. The outlines of the galaxies can only be made visible by using long-exposure photography. Galaxies predominantly arrange themselves into groups. Our group of galaxies, also known as "local group", consists of approx. 30 galaxies, which together form a radius of 2.5 million light-years. Not all galaxies have developed as spirals. Some are asymmetrical, others have are approximately circular or have an elliptical shape. The galaxies closest to us are constructed as somewhat asymmetrical mini- galaxies, known as the large and small Magellanic Cloud. These galaxies can be seen only from the southern hemisphere.

A well-known galaxy is in the constellation Andromeda. This can be seen with the naked eye. The galaxy is about 2.2. Million light-years away and looks like a misty speck. It consists however of a large spiral galaxy, similar to ours.

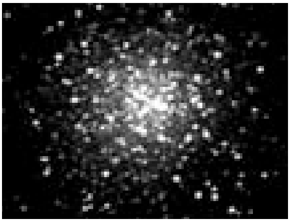


Fig 38: The Globular star clusters M13 taken by J.Newton

Star clusters

There are two different kinds of star clusters. “Open star clusters” which consist of bright, young stars which were formed from galactic nebulae (bright hydrogen and oxygen gases). The other form of star clusters are “the globular star clusters”. These are substantially larger and further away than the open star clusters. Both kinds can be observed using a small beginners telescope.

2.6 Practical observation tips and tricks

2.6.1 Preparations for the first night

An observation night needs to be well prepared. You should know your equipment and make yourself familiar with its operation in the daylight. Carry out a dry-run in setting up and also operating and testing any electrical accessories, such as a tracking motor or binoculars for finding the Pole star. When you come to set up the equipment at night you will save time and can concentrate on observation. It is also sensible to adjust the eyepiece telescope in daylight as it requires practice to do so at night. A far distant tower is a useful aid for setting up, also the choice of the observation place must be well thought out.

If you live in a large city you are forced to drive out into the countryside with your telescope. This is the only way to escape light flooding from street lamps and hoardings. A dark sky shows far more than the light-contaminated skies of a large city. People who live in the country have an advantage here. If we drive out into the country with the telescope, then we should first inspect the location in the daylight. Finally, you do not want to sink into a bog or be plagued by mosquitoes. Damp places should be avoided, as with rapidly sinking night temperatures the optics soon become misted up. A small hill is ideal and also offers an extensive view of the horizon. As far as cold nights are concerned you should always have warm clothing to hand. Once you are frozen through, then there is no more pleasure to be had. A thermos flask of or coffee or tea will help you to keep warm. What else should you also load into the car or into your bicycle panniers? Naturally the telescope and its accessories, a warm coat, hot beverages, a compass, a flashlight (covered with red cellophane) are important. Binoculars are also a welcome observation aid. In addition you should think of somewhere to sit. Take a folding chair or stool with you. A comfortable camping table will also prove very useful for laying out the accessories, for the star map material needs to be close by. You should examine it in the daylight and pre-select the celestial objects for the observation programme. This will make the subsequent search of the night sky easier. In the course of the time, you will notice that you will find your way better about the sky and will be able to find the more difficult celestial objects. To start with however, you should begin with objects which are easy to find and we will refer to these later.

After arrival at the observation site, setting up the equipment and orientation to North can be commenced, as described in the instructions. After approximately half an hour the eyes will become accustomed to the darkness and more stars can be seen than when we arrived.

It does not make sense to cancel out this adaptation of the eyes to the night by briefly looking into bright sources of light again. Furthermore, vehicle headlights or even the light of the flashlight are enough. The first should not be a problem, because we would not set up the telescope directly in a

Fig 39: A red LED lamp with clip

highway lay-by. In order to avoid the light of the flashlight, cover it with red foil. The red light only slightly disturbs night vision. Flashlights, which can be switched to give red light are excellent.

The telescope also requires several minutes, in order to adapt to the ambient temperature. Only then will the optics brings be fully operative. The circulation of air in the telescope tube during cooling makes the image waiver considerably, so after waiting for a while it is finally time to look into our telescope for the first time. It is best to use the low magnification eyepiece at first (long focal length), in order to have a larger field of view with the lower magnification. The required object will then be easier to find. Our first object could be, for example, the moon, or a planet, depending on what the sky has to offer us. If neither can be seen, then perhaps we can choose a double star or a star cluster, which we were able to find on the star map.

It does not matter which of these we select. The sky will not run away from us and there are many more nights of observation waiting for us.

2.6.2 Tips for the best observation conditions

The observation conditions play an important role during the observation with a telescope of the sun, moon, planet and stars. In addition the site of the observations is also significant, for example, the visibility conditions, as well as the condition of the telescope and the condition of the observer. Only when all observation factors are in order will it be possible for us to fully utilise all the optical abilities of our telescope. If we work under poor observation conditions, this can easily lead to disappointments and will give the impression that we have acquired a poor quality telescope. The following information and tips will help you decide whether the construction of the telescope is worthwhile or not.

The observation site

The observation site should be as dark as possible and be faraway from terrestrial sources of light (street lamps, headlights etc.). There should be all round visibility in all directions. Protection from the wind should be provided, so that the telescope will not "tremble". This is possible by using a suitable windbreak device, for example like those used when camping by the lake. We will rarely find an ideal observation place, without making a few local changes. In most cases we live in enclosed surroundings and our observation sites are the garden, the terrace or the balcony. In order to protect the site against the influences of light from terrestrial sources a sun umbrella can be used. A further possibility consists of placing a black cloth over the head and the eyepiece of the telescope, like photographers used to do in the early days of photography, so that they could see the picture in the camera clearly. Finally our observation place should be on firm ground, so that our telescope remains stable. Observation from the heated living room through a closed or open window is impossible. The window glass causes too much disturbance. In addition, the temperature difference between living rooms and garden would lead to streaks of moisture and thus to considerable disturbance, making it impossible to focus the object.

Viewing conditions

The local weather and the condition of the earth's atmosphere considerably affect the quality of the images in our telescope. When making astronomical observations we always look through the layer of air which surrounds the earth. Depending on the thickness of the surrounding atmosphere for instance it corresponds to us like the peel of an apple. If strong air turbulence is present and warm and cold air masses are mixed together, it is not possible to take meaningful observations with high magnification. We see this in the fact that the stars sparkle and twinkle in a range of colours. Especially during winter time turbulent air layers are immediately apparent.

A further feature is thin ice clouds at high altitudes, which similarly disturb our observations. These lead to coloured rings around the sun or moon.

The bright nights of the summer are also only partially suitable for the observation of faint objects. If the light of the moon illuminates the sky's background, we cannot expect to obtain the best performance from our telescope.

The best conditions in Central Europe are usually in the autumn and in spring if the sky is clear, the air layers calm and not clouded by vapour. The light from the stars appears calm with the naked eye and the sky background looks like black velvet.

Condition of the telescope

To allow the telescope to adapt to the outside temperature it should be set up and aligned in the open, about 30 minutes before beginning observation. During observation the lens or the mirrors can be affected by humidity. A hand warmer, available from specialist angling shops, can be used to remove dew from the lenses. A hair dryer can also do this well (if necessary a12V-model operated from a car cigarette lighter).

Under no circumstances should a cloth be wiped over the optics, because existing dust grains can result in scratches. One trick to stop misting up, is to use a protective lens cap to prevent dew. This which is clipped or screwed onto the front of the telescope tube. If not already provided, these can be purchased separately as accessories.

Fig 40: A lens telescope with a screw-on dew protection cap

Condition of the observer

Astronomical observing is not a high performance sport. It serves primarily to relax and provide new experiences. Make sure that you are fully rested. Observations in an overtired condition are not productive and cause stress to both mind and body.

A further word about our valuable organ, the eye. The full efficiency of the eye is only produced when night observations take place after approximately half an hour in the dark.

The diameter of the pupil of the eye, in young humans, can be up to 8 mm; experience has shown that the value decreases with age. Although the pupils adapt within seconds to the lighting conditions, the eye then needs up to 30 minutes, in order to fully adapt to the light, by means of the body's own chemical substances. With bright light this adaptation is lost within seconds and must again be developed. Therefore interference from light is to be avoided whilst observing, if possible.

A bright source of light, a headlight or a bright flashlight immediately destroy the eyes dark adaptation (night vision), so that we must wait again for half an hour, until we are best adapted to the darkness. Experience this just once and you will be amazed!

General points for observation:

1. Draw up a short observation list together. In this way you will not be stressed out in front of the sparkling heavens. Consider the reSpotting scope observation conditions. The full moon will spoil the pleasure of deep sky observations, even if you have a suitable observation place far away from terrestrial sources of light. In this case take brighter objects into the sights.

2. Do not choose too many objects. More is less! Look at the maps for finding your favourite objects well beforehand. In this way you will also quickly find them in the sky.

3. Use your binoculars to look at the sky and orientate yourselves. In the telescope, even with low magnification and reduced field of view, it is often not really easy. Practice.

4. Observe the objects you have found a little longer. Practice obtaining a relaxed view. Avoid the rigid view, let your eye float over the eyepiece. The longer an object is observed through the eyepiece, the more details open up to the eye. Often the optical light images are so weak that one learns and uses the full efficiency of the telescope with the possibilities it offers to see and perceive. The eye can also think. You will see more with increasing observation experience than at the beginning of your astronomical career. Even Galilei (1564 to 1642) and Newton (1643 to 1727) had to experience carrying out observations of the sky with small telescopes. Many followed them. You must also strive to follow them!

5. Keep an observation book, in which you record your impressions, either in writing or you can draw the objects on paper.

6. It does not always have to be a photo. You can draw the objects you have seen. Drawing is very popular among deep sky fans and is very suitable for the beginner, since astrophotography is often very difficult for the lay person. Different pencils and erasure techniques open up a whole range of objects for you. Compare your drawings with the photographs of the professionals and you will be surprised.

2.7 The most beautiful objects throughout the year

Winter

M42, the famous Orion nebula, is below the three belt stars of this distinctive constellation. This is a very bright emission nebula and a worthwhile object for every telescope!

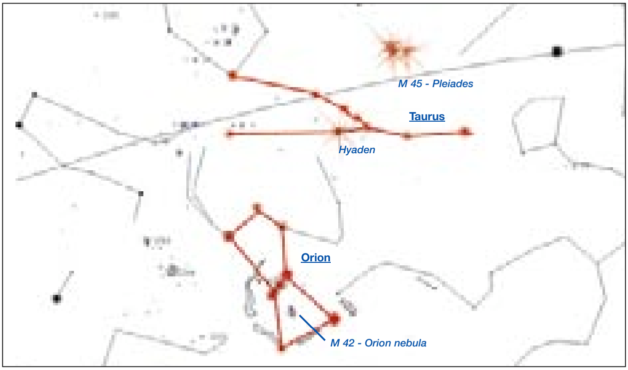


Fig 41 The seven daughters of Atlas, the Pleiades fleeing from Orion because he is so gigantic

The Hyades between "the horns" of Taurus and the Pleiades are large so-called open star clusters. In particular the Pleiades are remarkable even with the naked eye. They are northwest from Orion and can be observed with low magnification.

Spring

M 51, the so-called "Whirlpool galaxy", is somewhat below the left hand star of the handle bar of the Great Bear. This is a double galaxy, which can

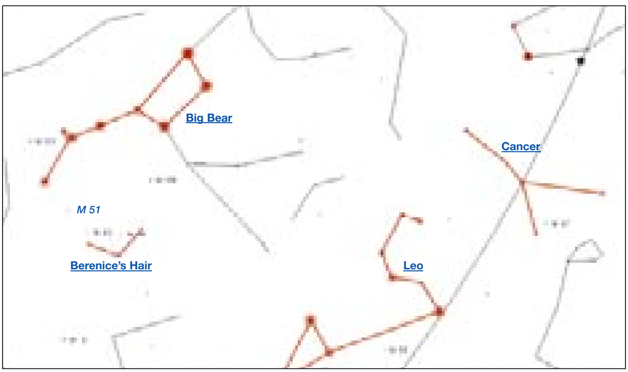


Fig 42: Berenice, the wife of the Pharaoh Ptolemy III, because of love, offered her magnificent head of hair to Aphrodite for the healthy return of her husband from the war.

Fig 43 The image of the Whirlpool Galaxy, M51 by J Ware

be clearly seen in a dark sky size with a medium telescope. It is better to drive out to rural areas for this observation. The light contamination of the city makes it very difficulty to observe this object.

"The Manger", M 44, is a large open star cluster in the constellation of cancer. The large planets Jupiter and Saturn often travel past in close proximity, since they lie close to the ecliptic; a very beautiful sight!

Summer

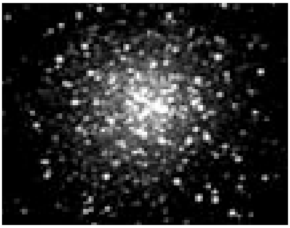


Fig 45: The globular star cluster M13 taken by J.Newton

M 13 in Hercules is the brightest globular star cluster in the northern sky. With high magnification individual stars can be seen, even with small telescopes.

M 57 is the famous "ring nebula" in the Lyre, the prototype of a planetary nebula. It is just below Vega, between the two lower edge stars. Slightly higher, east ofVega, is Epsilon Lyrae, a double, double star system!

Fig 46: Ring nebula M57, taken by M. Moilanen and A.Oksanen

Albireo, a very pretty double star with a clear orange-blue colour contrast which finally forms the head star of the swan. A worthwhile object for every telescope!

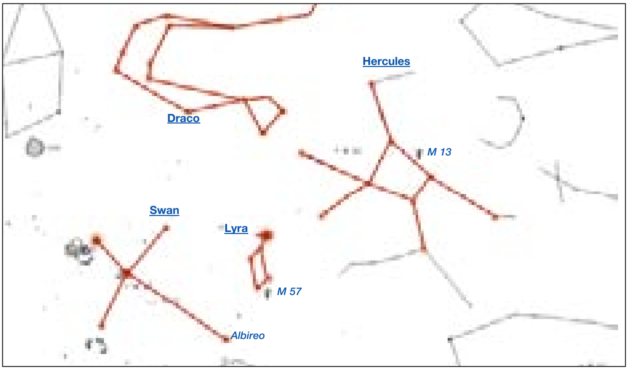


Fig 42: Hercules fights with Draco (the dargon) in the garden of the Hesperides

Autumn

Fig 47: The spiral galaxy M31 (in Andromeda), a photo by J.Ware

M 31, the Andromeda nebula with its approx distance of 2.2 million light-years is the closest and largest visible galaxy to us after the Magellanic Clouds of the southern sky. It is well over 3°wide in the sky (about the width of the thumb on an outstretched arm) and can be seen with the naked eye if the conditions are good. We know today that it is not a nebula, but a galaxy.

Somewhat more challenging is M33 in the constellation Triangulum. This galaxy repays patience at the telescope with many fine details.

h & χ Persei is finally a large double star cluster south of Cassiopeia. In the case of low magnification in the telescope or also in the binoculars it offers a splendid sight in either optics!

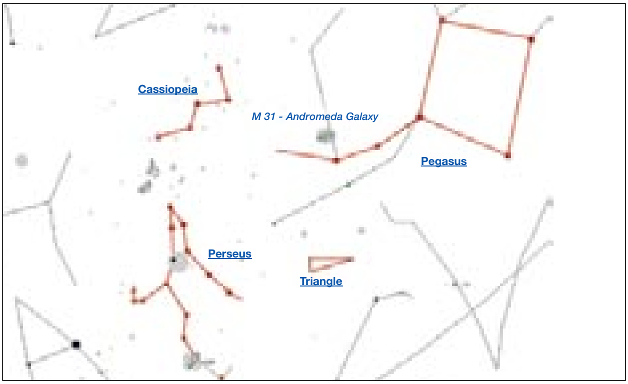


Fig 48: The winged horse Pegasus rising from Medusa, after Perseus had defeated her and then pulled the chariot of Zeus.

3. Bases of celestial mechanics

The movement of the stars

At first the beginner is disconcerted by the apparent movement of the stars. The stars maintain their apparent distance from each other, but they appear each night in a somewhat different position and then move on further. Some stars and constellations are visible all year round in the night sky, but others disappear. After a few hours in the western horizon, new stars and constellations then appear in their position. "The movement" of the stars is very slow and is hardly detectable by observers. If however a telescope with higher magnification is pointed towards a star, then the star will disappear after some minutes from the visual field of the telescope and one must "adjust" the telescope onto the new star position.

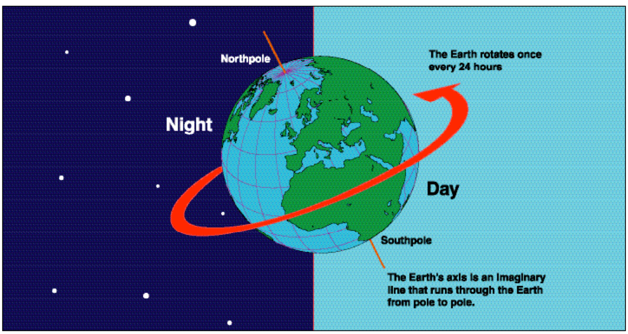


Fig 49: The earth rotates once every 24 hours on its own axis. The Earth's axis is not vertical, on the other hand, but is inclined by 23.27 ° from the plane of the orbit, in the direction of the sun.

An experiment can show very easily that the position of the stars change (evidence that the earth rotates):

Look for a bright star or constellation, which appears over a prominent point on earth, such as a house, a tree or a mast. Note the time and observe the position of the star or the constellation one hour later. What do you determine?

You will find that the stars moved westward with reference to the prominent point. They did not change their position to each other.

If you observe these star on the following nights at the same time, you will determine that they are positioned over the point approximately four minutes earlier each night. Does the earth rotate about its own axis more slowly than once in 24 hours?

Yes! It takes exactly 23 hours, 56 minutes and 26 seconds. This difference becomes balanced by the intercalary days.

Circumpolar stars and constellations

If we are on the fiftieth northern degree of latitude above the equator, then the celestial north pole is exactly 50 degree over the northern horizon. All stars, which are less than 50 degrees of arc from the polar star, never set below our horizon. We call these stars " Circumpolar". The more further south we are, the lower the Pole star is in the sky then the area covered by the circumpolar stars is decreased. At the equator there are therefore no circumpolar stars. Exactly at the North and South Poles however the stars neither rise nor set, but circle the horizon at a constant altitude.

Apart from the circumpolar constellations, the selection of available celestial objects depends on the season. By means of a rotating star map, one can determine the visibility of the constellations for the reSpotting scope observation places at each season. Previously mentioned yearbooks and technical periodicals offer further orientation assistance. After these

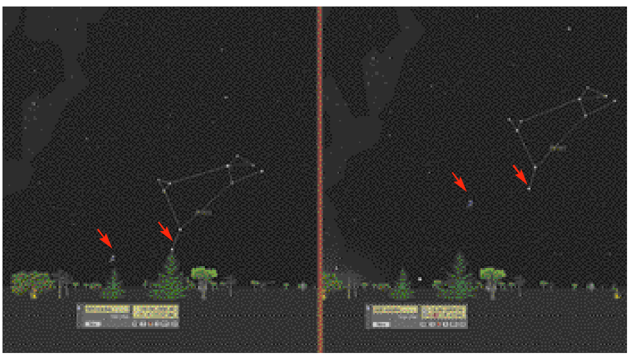


Fig 50: If at 4:15 (left) the Pleiades and the constellation are positioned above a prominent point, then it will be determined one hour later that they have moved westwards. However they have maintained their position relative to each other.

fundamentals we would now like to present some objects which are worth seeing. We are limited here to easy and moderately difficult objects.

Circumpolar constellations: The constellations of the Great and Little Bear, Lynx, Cassiopeia, Cepheus, Camelopardalis and Lizard never go down in our latitudes. One can observe them during each season. The observation conditions depend also on the observation date, because circumpolar constellations are positioned either low or high in the sky.

The Pole star is clearly visible at all times. It is very close to the celestial pole and is a double star, which many people do not do not realise. About 18 arc seconds from "Polaris " we can make out a small faint star. The Great Bear contains the most famous pair of double stars in the sky. Mizar and Alkor, which we already described in the introduction. The two can be readily identified and be checked with the naked eye, and have been used since long ago as eye testers. In the telescope we find a further companion beside Alkor, which is only 14 arc seconds distant and is a physical double star. Mizar and Alkor however are only spatially close together.

A deep red star can be found in the constellation of Cepheus. Because of its colour, μ-Cephei is called the garnet star. b-Cephei is a beautiful double star. Two stars of differing brightness stand at a distance of 13 arc seconds apart.

The five brightest stars in Cassiopeia form the remarkable "W" in the sky. With binoculars we can make out the open star clusters M103 and M52, which are members of our Milky Way.

h Cassiopeia is a double star. A yellowish and a reddish star circle each other at a distance of 13 arc seconds.

Circum polar stars and polar star photographed

Circum polar stars can be make visible photographically. The best time is at the beginning of the year. In the summer the night is too bright for such photography.

Telescopes with equatorial mountings and tracking motors or computer control are suitable for astrophotography.

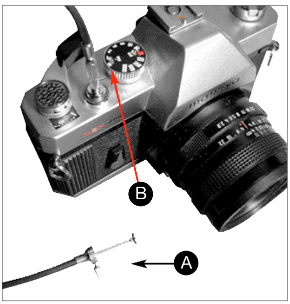


Fig 51: A SLR-camera with cable release (A). The exposure time is set to "B"

You will need a camera with a cable release, a sensitive film (400 ASP/27 DIN or less is sufficient) and a stable stand. It is important that the shutter of the camera has a control for selecting the exposure time "B"(arbitrary). This way we can leave the shutter of the camera open for any length of time and expose the film over a long period.

Insert the film into the camera, set the sensitivity of film and turn the wheel for the exposure time to step "B" .The camera is now attached to the stand and aligned onto some bright stars. Screw the cable release into the trip button. Set the focus to infinity. The diaphragm is completely opened. Open camera shutter for at least 30 minutes by pressing and tightening the camera release. Depending upon the sensitivity of the chosen film, you can take such a picture with up to, or over two hours exposure time. Lock the cable release after pressing, with the locking screw. When the time has elapsed, simply loosen the locking screw again and the shutter closes again.

A useful trick before you operate the cable release, likewise before completion of the exposure, is to cover the camera objective with a dark cardboard box. In this way you will not blur the picture and the lines and/or star arc created and will not show serrations at the beginning and at the end of the exposure. During the exposure time the view finder of the camera is not available.

If you bring the film to your dealer for developing, be certain to point out that these are astronomical photographs, otherwise the pictures will not be processed using automatic development. Try different exposure. Experiment!

On the photographs it becomes visible that the stars turn along different paths apparently around a central point. This central point is the pole star.

With stars, which are visible as circular arcs in the photo are the previously described circumpolar stars, i.e. these stars are always to be seen

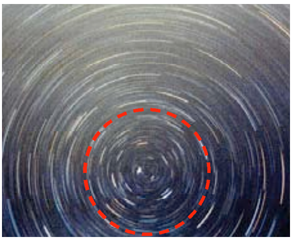


Fig 53: The same picture as the one on the right, showing here the stars of the circumpolar regions, which never sink below the horizon.

Fig 52: During the exposure of the film the stars continue to move in the night sky. In this photo by M. Stoelker – which was taken in the spring, it can be seen which stars disappear beneath the horizon in a short period of time, that is "sink". 2 hour exposure, taken with a 400 ASA Film.

in the night sky and they never go below the horizon, they always circle the pole area of the sky.

In which part of the sky do we find the "circumpolar" stars?

If we turn northwards, we will find the constellation of the Great Bear. This constellation is "circumpolar" i.e. we can see it each night at all times in the sky.

Depending upon the season, the Great Bear is sometimes close to the horizon and sometimes can be seen almost vertically above us. Whatever the position might be, the two stars "at the front of the plough" always point in the direction of the pole star.

If we imagine a line, which extends from the Pole star perpendicularly to the horizon, it will meet the horizon at the so-called North point. All stars, which lie between the Pole star and the North point, will never dip below the horizon. They are visible throughout the year, these are circumpolar stars.

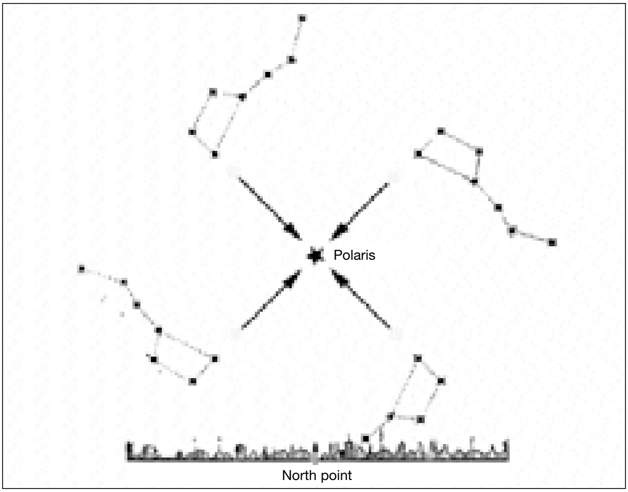


Fig 54: The graphic shows the area of circumpolar stars between the Pole star and the North point.

3.1 Why does the sky change throughout the year?

If you imagine, your telescope is firmly set up and points at a certain time to Sirius, which is the brightest star in the northern sky, then you will see Sirius again after one complete earth revolution again in the eyepiece and in you will see that it is moving. The earth actually rotates once around its own axis in 23 hours, 56 minutes and 26 seconds. If we looked in the eyepiece 24 hour later, then we would have missed the passage of Sirius in the eyepiece by exactly 3 minutes and 34 seconds. For this reason a bright object such as Sirius rises daily exactly 3 minutes and 34 seconds earlier. In ten days that is approximately 35 minutes. The same applies for the other non circumpolar stars. The same also naturally applies to constellations, which rise daily about 4 minutes earlier.

Observe Sirius, the main star in the Canis Major Constellation above a prominent point on your visible horizon and make a note daily over a period of around ten days at which time it is in this position. After ten days Sirius would be in this position about 35 minutes earlier. The duration of one revolution of the earth is called an astronomical Earth day or also a sidereal day.

For the sake of simplicity we have divided the day into 24 hours and we therefore accept that the constellations in the course of a year will move day by day and so will the typical spring summer autumn and winter constellations seen during the evenings.

3.1.1. Why are there intercalary days and leap years?

Our sky, in the astronomical sense, is very varied, because in the course of orbiting the sun the Earth describes one plane around the sun and thereby moves in a circular path around the central object of our solar system.

During this orbit the earth rotates 365 times about its polar axis, therefore 365 sunrises and sunsets and somewhat less than 6 hours will go by. It was agreed many years ago that as far as the calendar is concerned, there would be 365 days in a year. Nature however requires a few more hours.

Every four years we acknowledge this time deficit in the duration from 365 days and every four years an additional day is added onto our calendar.

This way we prevent the seasons from being pushed back, in terms of the calendar, one day every four years. Your birthday remains, for example on 27th August, nothing changes . The weather however changes. In the spring there is a date, that is to say a calendar day when the sun is visible above the horizon for twelve hours and is below the horizon for twelve hours. Spring begins on the 21st of March each year. In relation to annual weather this means a constant shift of the weather periods for all calendar months, once in, for instance, 365x~4 years. A certain birthday, for example in the summer on the 5th July would move into spring. There are a great many customs and traditions, and cultural rites everywhere in the world, which depend to a large extent on the weather. By adding an additional day, the intercalary day, these celebrations and events remain on the prescribed calendar date and places the beginning of spring punctually every year on March 21st.

This point in time is referred to both as the date of the first day of spring and also the first night of spring. The sun remains central during this period always at a certain point in the sky, for the first day of spring. If one did not add the intercalary day every four years, the sun after four years would reach the point for the first day of spring on the 22nd March, thus one day later, therefore the beginning of spring would move every four years by one day. Please do not confuse this with the fact that the rotation of the Earth takes a little less than 24 hours.

The rule that a day has 24 hours and that the year represents exactly 365 days is just a practical simplification for mankind. One Earth year (astronomical) and one terrestrial year (calendar) are therefore different.

The spring:

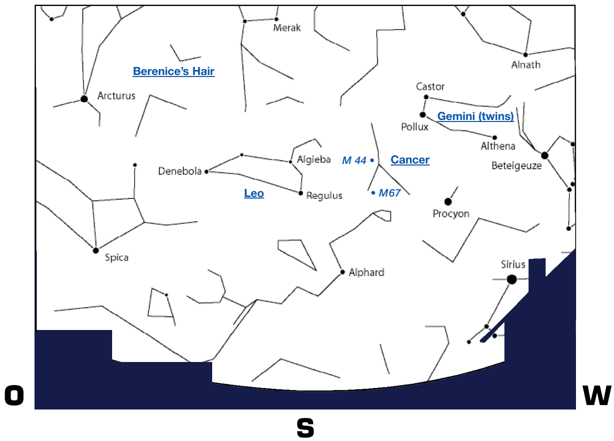
The dominant constellation in the spring sky is Leo (the lion). Leo is easy to recognise, it has a very distinctive appearance. In the constellation of Leo are to be found several galaxies, which are not very easy to find because their brightness is not very great. It involves M65,M66 and also M96, all of which are spiral galaxies.

Somewhat to the west of the constellation of Leo, the constellation of Cancer can be found. Cancer is a rather inconspicuous constellation, in which there are two beautiful open star clusters. The splendid Manger or Beehive, as the star cluster M 44 is popularly called, is reduced in the binoculars into a beautiful single star. It is possible to see at least 40 stars approximately 500 light-years away. A little further south the open star cluster M 67 can be found, which is substantially smaller, but is nevertheless impressive because of its high concentration of stars. The star cluster is about 2,700 light-years distant.

East of Leo can be found the constellation of Berenice's Hair and to the south lies Virgo. The attraction of these constellations is the Virgo Cluster. If the telescope is pointed towards the Virgo Cluster and if the area is carefully examined, some small blurred "stars" can be seen. These are a distant galaxy, which can often only be recognised as a galaxy after very careful observation. The distance of this galactic cluster is also over 40 million light-years away.

This is obviously only a small part of the visible sky. A view of a detailed star map reveals an abundance of further objects. The still comparatively

Spring



dark nights in the spring and often surprisingly good weather can often make these nights very entertaining. Somewhat to the west of the constellation of Leo, the constellation of Cancer can be found. Cancer is a rather inconspicuous constellation, in which there are two beautiful open star clusters. The splendid Manger or Beehive, as the star cluster M 44 is popularly called, is reduced in the binoculars into a beautiful single star. It is possible to see at least 40 stars approximately 500 light-years away. A little further south the open star cluster M 67 can be found, which is substantially smaller, but is nevertheless impressive because of its high concentration of stars. The star cluster is about 2,700 light-years distant.

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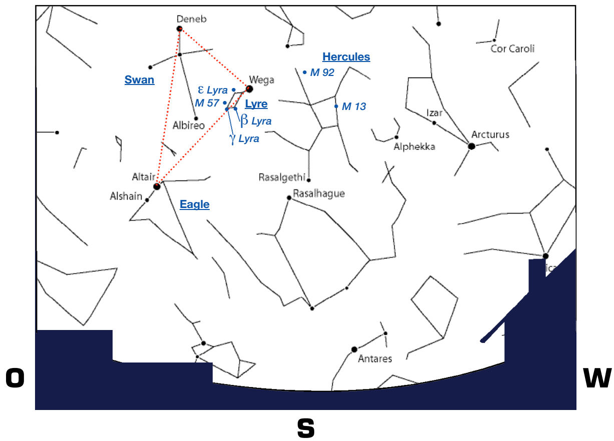
This is obviously only a small part of the visible sky. A view of a detailed star map reveals an abundance of further objects. The still comparatively dark nights in the spring and often surprisingly good weather can often make these nights very entertaining.

The summer:

In the summer it becomes dark either late or never absolutely dark. This is not advantageous for astronomical observations. Clear weather and pleasant temperatures make observing fun. Moonless nights are still dark enough in the summer to admire the Milky Way. Even with binoculars one seems to drown in the sea of stars. Relax! With its many open star clusters and gas nebulae, the Milky Way provides much entertainment. The three main constellations, whose main stars are referred to as the summer triangle, are the Swan, the Lyre and the Eagle with their bright stars Deneb, Vega, and Altair. The constellation Swan, which lies within the Milky Way band, has one of the most beautiful double stars of all. The pair of stars is called Albireo and represents the head of the swan. At a distance of 34 arc seconds there are a yellowish star and a sapphire-blue star. They are easily recognised by their different colours.

In the constellation in the Lyre there is another beautiful double star to be found, called ε-Lyrae. ε-Lyrae is close to Vega. The two components stand

Summer



apart, that is nearly 1/10 of the moon's diameter. With high magnification and good seeing one can separate the two stars into two closely neighbouring stars, which are distant from each other by about two and a half arc seconds. Here we have a genuine four-fold system, that is to say stars which form a gravitational system similar to the Earth - Moon system.

Fig 46: Ring nebula M57, taken by M. Moilanen and A. Oksanen

Probably the most well-known object in the Lyre is the Lyre Ring Nebula or M57. In order to find this jewel, we must point our telescope at γ-Lyrae and then slowly move in the direction of ε-Lyrae. With low magnification, a faint smoke ring can be seen half way. With higher magnification the structure of the ring becomes clearer. This object is a planetary nebula, which does not have anything to do with planets, however, despite the name. One sees the dust and gas of an imploded star, which became a white dwarf which shines due to the hot remains of the star.

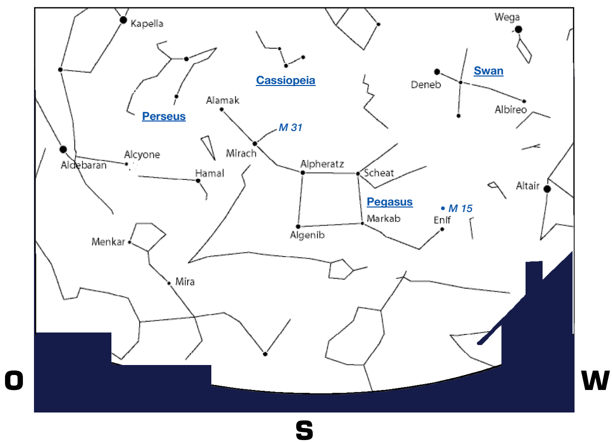
West of the Lyre is the constellation of Hercules, which also contains two objects from the Messier Catalogue. One is the globular star cluster M 92 and the other is the globular star cluster M 13, which qualifies as the most beautiful globular star cluster of the northern skies. M 13 can be identified with the binoculars as a small, blurred "star", but in the telescope reveals its true beauty in the sky. In a small telescope the edges of the single stars can be seen.

Even with binoculars we can penetrate deeply into the band of the Milky Way. If we move the binoculars to the south towards the Sagittarius constellation, then we can discover gas nebulae and star clusters with a good view of the horizon. Amongst them, for example, the Wild Duck Cluster is in the constellation Scutum, which qualifies, with many amateur astronomers, as their favourite object. In addition the Omega Nebula and the Eagle Nebula also qualify. They consist of enormous hydrogen clouds and are the birth place of the stars.

The autumn:
In the autumn, slowly the summer constellations say good-bye and after midnight we already risk the possibility of a view of the forthcoming winter sky. The appreciably longer nights allow astronomical observations to be started in the evening. The most remarkable constellation in the autumn is Pegasus. Pegasus has galaxies to offer, which shine very weakly however. The globular star cluster M 15, is well worthwhile. This is 31,000 light-years distant. M 15 is not as impressive as M 13, but can in addition, be separated into individual stars.

East of the constellation of Pegasus is the constellation Andromeda. In this constellation is one of the most famous galaxies of all, the Andromeda

Autumn



Nebula or M31. These are 2.2 million light-years distant and the spiral nebula is already recognisable on dark nights as a blurred "star". However, with the telescope the bright core of our neighbouring galaxy can be seen. Because of the size of the object in the sky, one can only bring part of the galaxy into the visual field of the telescope. If one looks in the region of the core, you will see more detail of the spiral arms. The Andromeda Galaxy has two companion galaxies, which can be easily recognised. One is the galaxy M 32 and the other the galaxy NGC 205, both are elliptical galaxies.

The constellations of Cassiopeia and Perseus in the autumn are very high in the sky. The two constellations are still located in the Milky Way and offer some beautiful open star clusters. The most beautiful star cluster, perhaps even the most beautiful of all, is in the constellation of Perseus. It is the double star cluster of h and Ã Persei (NGC 884/NGC 889). These two are located only 50 arc minutes apart and can be recognised in the binoculars as a pretty couple. You can view this object, which is very beautiful to see, in your telescope with less than times 50 magnification. We can then see a double star cluster, 8000 light-years away, with approximately 400 stars.

The Winter:

Because the nights begin early in the winter, work can commence early in the evening. A great deal of love for the hobby is required at temperatures below zero degree. The correct clothes, warm drinks and a place for warming up, are good preconditions for a pleasant night of observation. The observation in cold winter is worthwhile, because the winter sky has to offer some spectacular views. The constellations Charioteer, Taurus, Gemini and Orion dominate the winter sky with their bright stars. These constellations have still more to offer however. Have a look at the constellation of Taurus, which has two bright open star clusters. On the one hand Taurus presents the Pleiades, which are also known as the Seven Sisters, on the other the Hyades, in whose centre the bright star Aldebaran is located. The Pleiades consist of at least 500 young stars, which were formed over 100 million yeas ago. With the naked eye one can

Winter

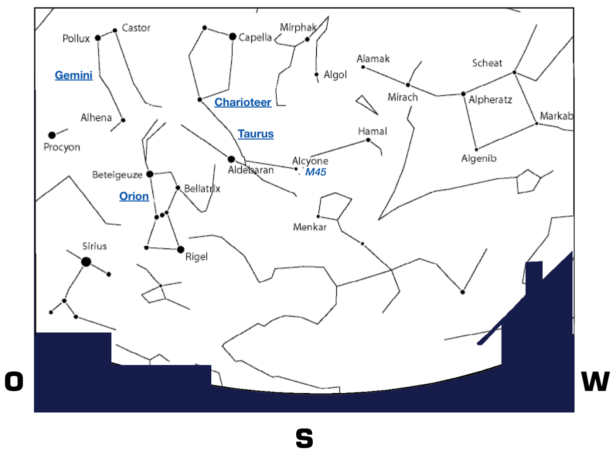


Fig 30: The Pleiades open star cluster M45 from C.Kimball

see at least six stars, with good conditions up to nine. The Pleiades (M 45) are close to the plane of the Earth's orbit and therefore now and then get a visit from the moon, which leads to interesting star cover. The Hyades also represents an open star cluster, which is close to the level of the ecliptic, This is how we refer to the path, which is described by the annual orbit of the earth around the sun. The moon also regularly passes through. The star Aldebaran is not Hyades star, it stands spatially in front of the Hyades.

In the Taurus constellation the object M 1 is located. This is the first entry in the Messier Catalogue. M 1 is the remnants of a supernova, which occurred in the year 1054 AD and was recorded in writing in China. Because of its appearance, M 1 is also known as the Cancer Nebula. In the centre of the Cancer Nebula is a fast rotating Pulsar, which energizes the surrounding materials and causes them to shine.

Fig 55: The Cancer Nebula, M1, taken by J.Newton

The constellation Charioteer (Auriga) lies in the Milky Way and offers several open star clusters close to the bright star Capella. These are not as bright as the Hyades and Pleiades, but are however worthwhile objects because of the wealth of stars. These are the star clusters M 36, M 37 and M 38 from the Messier Catalogue, which look like nebulae in the binoculars.

One of the most well-known winter constellations is the Constellation Orion, which reminds us of the sky hunter Orion in Greek mythology. The three belt stars, which is known as also Jacob's staff are prominent. The Orion Nebula (M 42) is a most remarkable object which symbolises the sword of Orion, the mythical sky hunter. The nebula is the brightest gas nebula in our sky. An enormous hydrogen cloud becomes illuminated by young, hot stars. In the middle in the Orion nebula can be seen a constellation of four stars, which are called trapezoidal stars. In larger telescopes two further stars are visible. The Orion nebula is 1,600 light-years distant and has a diameter of over 66 arc minutes. It is four times larger in the sky than the disk of the full moon. In the telescope,however only the bright centre can be seen.

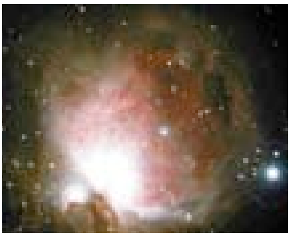


Fig 56: The Orion Nebula, M42, taken by C.Kimball

Southeast the constellation of Orion, is the constellation of the Great Dog (Canis Major). In it is the brightest star in the sky. The Dog Star, also called Sirius, flickers in a whole range of colours due to its proximity to the horizon.

North of the Constellation of Orion is the constellation of the Twins. The star Castor ranks as the brightest stars of the Twins. In the telescope Castor can be seen as double star. The two stars are only 3 arc seconds in the sky from each other. A beautiful object in the Twins is the open star cluster M 35, which can be seen in the binoculars as small nebula spots.

3.2 Use of the rotating star map

Fig 57: The rotatable star map is a practical aid for planning an observation session

In order to be able to plan observation nights better, there are practical rotating star maps, manufactured from plastic or cardboard, in addition to star map software for computers. The observation date and the desired observation time are set on a scale along the edge of the circular star map. A circular template cut-out window indicates the section of the sky, which will be visible on the observation day at the desired time. Here we will describe briefly, how to deal practically with such maps. It is important to mention here that different maps for the Northern and for the Southern Hemispheres of the Earth must be purchased. This must be borne in mind when obtaining a map.

Important

Local time on swivelling star maps is set for the northern hemisphere for

Fig 57: The rotatable star map is a practical aid for planning an observation session

Central Europe. For the star map Central European Time (CET) applies. During the summer time, please subtract one hour from the local time (this is to convert from winter time to summer time).

When it must be very precise:

Determine the degree of longitude of your location (e.g. 10° East for Hamburg) and the difference between the reference meridian for the CET (15° East). Thus 15° – 10° = 5°, you then multiply this difference by 4. The result is the number of minutes, which you must subtract from the CET. You have now specified the so-called, true local time at your observation site. You can now set this onto the star map.

This data can also be obtained from the internet. The web page www.heavens-above.com is such an efficient data base.

What can I see at the moment?

Turn the top of the star map in such a way that the CET or the true local time coincides with the current date. Now turn the entire map so that the appropriate horizon (north, south, east, west) agrees with your own line of sight at your geographical location. Now the cut-out on the map will show the actual sky to be seen at that instant.

Where is the position of the sun?

Turn the pointer so that it coincides with the current date. Where the pointer now cuts the line of the ecliptic (the apparent path of the sun in the sky), is the present position of the sun, seen from your location.

When will it become light or dark? Locate the position of the sun, as described above. Now turn the top of the map so that the place of the sun coincides with a dawn line. The rotating star map is now set accordingly. The following apply:

- civil dawn - brightest stars recognisable
- nautical dawn - constellations recognisable
- astronomical dawn - beginning/end of darkness

Where is the moon or planets positioned?

Look up in an astronomical yearbook the coordinates of the desired planet. Now turn the pointer, until the right ascension (hour value) of the planet is set on the hour circle. The declination, that is the angular height above the celestial equator (expressed in degrees) is read off from the pointer scale. Note: The moon and planets are always on, or close to the ecliptic. That has to do with the history of our solar system.

To determine the present sidereal time

Sidereal time (ST) is needed to point the telescope on celestial objects using coordinates. Turn the top of the star map so that the date and local time coincide with each other. Turn the pointer so that it points exactly to the south point on the map. Now you can read off the sidereal time (hour angle of the point of spring) from the hour scale.

3.3 Why can we only see part of the sky?

The answer is very simple. The earth is a sphere and lying in the meadow looking into the sky, we cannot see laterally towards the horizon around the Earth's curvature. We are presented with a sky, which can be described spatially as a very large transparent hemisphere. The Earth's curvature can be seen in coastal regions, on the beach, with binoculars or telescope, We can see sailing boats rising above or disappearing below the horizon, without damage, as a consequence of the Earth's curvature. Because the earth is of spherical shape, only half of it is illuminated by the sun at any one time. The opposite side is in shadow and forms the night side, so we only able to see half of the sky from the earth.

3.3.1 The eyes' field of view

On the other hand, with our eyes we can only see at the most a field of vision of an angle of 110°. Of this only 5° can be seen sharply with healthy eyes, which are however controlled, more or less unconsciously, in such a way that whatever is of interest to us is centred automatically into the 5° range. As the visual field of an eyepiece is much smaller now than the total visual field of the eye, then one speaks of so-called tunnel vision: one sees only a small area, surrounded by blackness. Good, standard eyepieces have a visual field of approx. 50°, which can be comfortably observed. In addition, there are also wide angle eyepieces with a visual field increasing to over 80° - giving the impression when observing of not looking through the telescope but almost floating in space past the object, as the eyepiece illuminates nearly the entire visual field of the eye.

4. Telescopes

4.1 The telescope as observation instrument

In order to get an idea of how it is used to observe the sky, it is necessary to dedicate a few sentences to the tasks of a telescope. If one believes the advertisements, the telescope is a magnifying glass, which shows the sky up to a magnification of 600 times or more and spoils us with multi-coloured gas nebulas. During practical observations we will very soon realise that this is not the case. On the contrary, magnification is important, but not the crucial factor for the efficiency of your instrument. The ability to collect light (light intensity) and the image contrast of the optics are important features, which distinguish good telescopes. There are several designs of telescopes, all of which have their pro's and con's. Unfortunately there is no "Jack of all trades", which satisfies all needs.

We will begin briefly running over the designs of telescopes. We will divide them simply into lens telescopes and reflector telescopes.

Refractors (lens telescopes) mainly consist of an objective, consisting mainly of two lenses, which are only separated by an air gap (achromatic lenses). The objective collects the incoming light and bundles it into the focal point. An eyepiece at the focal point magnifies the image. The distance between the objective and focal point is called the focal length.

With reflectors (reflecting telescopes) the task of the objective is taken over by a concave reflector curved inwards (parabolic). The reflector is in the rear part of the telescope tube. Similarly, it collects the incoming light and bundles it into the focal point. Between the focal point, where again the eyepiece is located, and the main reflector, is a catch mirror (secondary reflector), which returns the bundled light to the eyepiece. There are essentially two designs of reflector systems. With the Newton reflector telescope, light is laterally deflected through 45°. The eyepiece is in the upper area of the tube and usually one looks sideways into the telescope.

Fig 58: Lens beginners telescope, Fraunhofer design. Achromatic with 70mm aperture.

Fig 59: Reflector beginners telescope, Newton design. Reflector with 114mm aperture.

Fig 60: Advanced reflector telescope. Schmidt-Cassegrain design with 203mm aperture

With Cassegrain telescopes the main reflector is centrally perforated. The catch mirror is also centrally installed in the path of the rays opposite the main reflector at the front end of the tube and reflects the image back through the perforation in the main reflector to the tube towards the eyepiece. The eyepiece is, as with the lens telescope ,situated at the rear end of the tube.

Both designs have their advantages and weaknesses. The decision to purchase a telescope must be made by the astronomer, depending upon the operational area and the size of your budget.

Refractors are superior in terms of the quality of the image than the reflecting systems of the same size. They are do not easily go out of adjustment and therefore require very little maintenance. These characteristics make the lens telescope the ideal instrument for a beginner.

4.2 Optics

In principle there are two optical concepts with astronomical telescopes: the reflector telescope and the refractor telescope (lens telescope)

4.2.1 Refractor (lens telescope)

A lens telescope consists of an objective lens and an eyepiece. It is important that the objective lens is achromatic (double lens with air gap). The diameter of the objective lens is along also decisive in determining the light intensity of the telescope. Advantages of a lens telescope over a reflector telescope are set out below.

a) no light loss caused by the shadow of the catch mirror (obstruction) as with reflectors
b) outstanding image definition

4.2.2 Reflector (reflecting telescope)

The most common design of reflector telescopes is named after its inventor, Sir Isaac Newton (1643 to 1727). Newton reflectors possess one spherical – or with better designs parabolic – polished, concave reflector, whose surface is coated with aluminium. The rays of light are deflected through 90°, after being reflected by the main reflector, shortly before the focal point, by means of a plain, 45° inclined catch mirror. The focal point therefore lies outside the main tube in which the eyepiece is located.

Which is better – the lens telescope or the reflector telescope?

It is very difficult to give an answer for amateur purposes. As a general the rule of thumb, a reflector telescope with a particular aperture is of slightly lower quality in terms of image and image resolution than a lens telescope with the same aperture.

4.3 Mechanics

In a telescope a whole number of quite diverse mechanical construction groups are built together, which do not differ in their methods of construction and function, but also in their operation. We have already mentioned that a sturdy stand and a solid mount are essential for a satisfactory observation of the sky. There are different basic types of mount, which are described in more detail in the following.

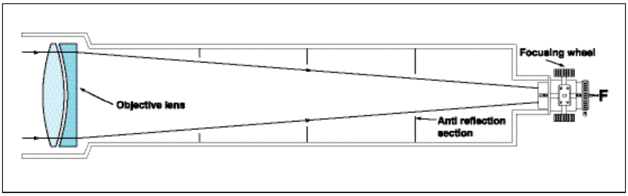


Fig 61 The optical construction of a lens telescope contains an optical design in which the light comes from the left through a pair of objectives and is focussed at the focal point (F)

4.3.1 Azimuth mount

With the azimuth mount the telescope body, also known as the optical tube, is hung in a fork and the tube can be moved horizontally and vertically by the user. The azimuth mount is recommended for the astronomical beginner, because objects in the sky can quickly be found with ease.

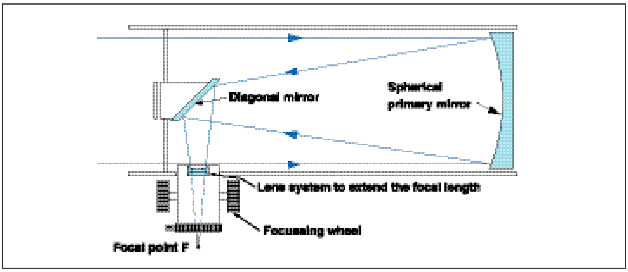


Fig 62: The optical design of a Newton reflecting telescope containing a focal length extension, achromatic lens system, that enables the combination of longer focal length and ashorter telescope tube.

4.3.2 Parallax or equatorial mount

More complex telescopes are usually fitted with an equatorial mount. Adjusting is made by two swivelling axes positioned perpendicular to each other (declination and right ascension axis). Equatorial mounting is carried out with one axis, the right ascension axis being pointed at the Pole star and clamped. Orientated in this way, the mounting with the tube installed can only be adjusted only in one axis, just the right ascension axis and thus compensates for the rotation of the Earth. Thus the object in the eyepiece always remains in the centre of the visual field. A tracking motor adjusts the rotation of the Earth around its polar axis exactly in the opposite direction. There are many different models of these engines available from specialist dealers.

Fig 63: An azimuth mounted telescope.

The adjustment of the mount (the right ascension axis), the telescope tube on the polar star and the further handling of the mount requires knowledge of the coordinates in the sky, together with practical

Fig 64: A parallax mounted telescope.

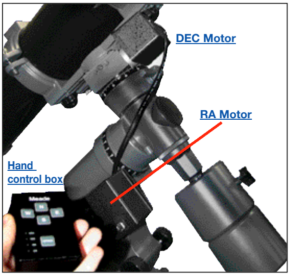


Fig 65: A parallax mounted telescope with tracking motors

Fig 66: There is the right accessory for every purpose to be found within the range of accessories from the various manufacturers

experience in astronomy. For astronomical photography an equatorial mount is absolutely necessary.

4.3.3 Tracking motors

If the telescope is fitted with an equatorial mount, then often electrical tracking motors can be attached.

A tracking motor is recommended for the right ascension axis, thus enabling synchronous adjustment of the apparent star movement in the sky to take place.

A tracking motor for the declination axis makes observation very comfortable – but is not absolutely necessary. The declination gives the height of a star in degrees of arc above the celestial equator.

4.4 Accessories

For the variety of telescope types, there is just as large a variety at optional accessories. For the beginner the question soon arises, for example, which accessories are important, which are useful or which are completely useless? Always be clear of the type of telescope you possess, which observations would you like to carry out and whether you would like to depart from visual observation and take the first steps towards astrophotography.

4.4.1 Eyepieces

The task of a telescope eyepiece is to magnify the image, which is produced by the main optics of the telescope. Each eyepiece possesses a certain focal length, which is expressed in millimetres (mm). The shorter this focal length is the higher the magnification. An eyepiece with a focal length of 9mm, for example, gives higher magnification than an eyepiece with a focal length of 26mm.

4.4.2 Important tips on selecting the eyepiece

The quality of an eyepiece is determined, irrespective of its focal length, by its apparent visual field, the manner of viewing and the suitability for fast aperture speeds (large aperture/short focal length).

The apparent and absolute visual field

The apparent visual field can be described as the angle, below which one can see the image produced by the telescope. As an example if we take an eyepiece with a visual field of 10°, this value of 10° is only a fraction of the image field, which the eye can see. The image appears as though it is viewed through a long tube. With a visual field of 70° we are approaching the angle, which our own eyes can see. A view of such will resemble a clear view through a window, with only slight curvature around the edges.

Eyepieces with low magnification offer a large visual field, brighter and high-contrast images and strain the eyes relatively little, even with long observation sessions. In order to lay-on an object with the telescope, it is advisable, to begin with a low magnification eyepiece – like for example the super Plössl 26mm. Once you have laid on to the desired object and have it in the centre of the visual field, you can soon change to higher magnification eyepiece. Thus you can enlarge the image as far as the prevailing observing conditions allow.

This visual field is calculated (approximately) by the apparent visual field of the eyepiece (e.g. 60°) and the current magnification of the telescope with this eyepiece. Example: visual field 60°, enlargement 100x, thus 60/100 = 0.6. That means, the actual visual field amounts to 0.6°. So-called wide-angle eyepieces therefore offer, when the magnification is the same(if the focal length is identical), a larger visual field and also a more comfortable view.

The view behaviour

The viewing behaviour of an eyepiece is of the greatest practical importance for observation. The more easily and more uncramped one can see the object, the more frequently the eyepiece will be used. During the day you can very quickly find the visual field of an eyepiece, it stands out as a bright disk in the eyepiece. At night the situation becomes more difficult. The image of the object is dark, the eyecup of the eyepiece is black and all around is also dark . If the view behaviour is not the best, then once it has been found the eye must be kept exactly behind the eyepiece, otherwise the image will disappear again. This leads to a cramped attitude, which makes observing uncomfortable.

The minimum magnification:

A telescope collects light and passes it on to the eyepiece, which passes it on and concentrates it at the focal point. The eyepiece therefore supplies light bundles to the eye, the so-called exit pupil (EP). This exit bundle may not become infinitely large. If the exit pupil becomes larger than the pupil of the eye, then light is lost.

The size of the exit pupil can be calculated thus:
Exit pupil = Eyepiece focal length in mm x Aperture ratio

Example: The brightness of a celestial object in the eyepiece does not depend on the magnification, the focal length or the aperture of the telescope, but exclusively on the diameter of the exit pupil. Its diameter (the larger, the brighter) is calculated as follows:

Focal length eyepiece : Aperture ratio telescope.
Example: Telescope with f/10, eyepiece with 40mm focal length.
40 : 10 = 4 mm exit pupil.

Note:
The exit pupil of an eyepiece should not be larger than 7mm as the human eye cannot take more. This would cause light loss (loss of image data).

The maximum sensible exit pupil therefore lies at approx. 6mm and the minimum at 0.5-1mm. If the EP becomes smaller, errors occur in the glass bodies and the tears can be formed in the eyes.

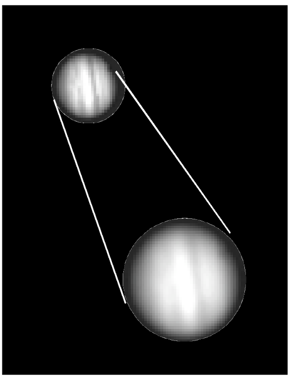


Fig 67: The planet Jupiter with the correct, sharp magnification, above and with the incorrect blurred magnification

The magnification correctly calculated:

The magnification of a telescope results from the focal length of the telescope and the focal length of the eyepiece in use. To calculate the magnification of the appropriate eyepiece you divide the focal length of the telescope by the eyepiece focal length. Let us take a 26mm eyepiece as an example. The focal length of our telescope amounts to 2000mm. Now we calculate as follows:

$$\textbf{Eyepiece magnification} = \frac{\text{Telescope focal length}}{\text{Eyepiece focal length}} = \frac{2000\,\text{mm}}{26\,\text{mm}} = 77\text{x}$$

The enlargement with this eyepiece amounts therefore to approximate x77

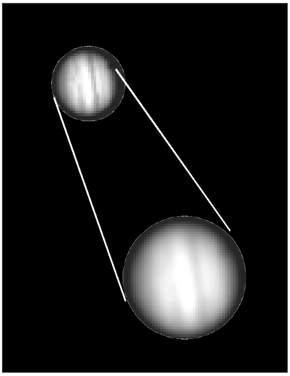


Fig 67: The planet Jupiter with the correct, sharp magnification,above and with the incorrect blurred magnification

View through a Plössl eyepiece

Plössl eyepieces are very popular owing to their high image definition and good contrast. They are mostly used as a beginner's telescope for normal observations lasting 1-2 hours. They have very good image definition and acceptable view behaviour. In the picture on the left you can see an example of how large the visual field is.

Can one ever select too high magnification?

Yes, one can! The most frequent error, which is committed by beginners is to over magnify the telescope. A very high magnification is selected, which the construction of the telescope, the weather conditions or the light conditions cannot provide. Therefore please always keep in mind that a really sharp, but less magnified image is much more beautiful, than a highly magnified, but completely blurred image and it will not give you much pleasure (fig. 67). Magnification over 200x should be chosen only with absolutely calm and clear air.

Most observers have three or four additional eyepieces handy, in order to use the telescope over the entire range of possible magnifications.

Rule of thumb for max. useful magnification: Objective diam. (mm) x 2

Note:
The viewing conditions vary very significantly from night to night and depend quite considerably on the observation place. Air turbulence arises during very clear nights and distorts the images of the objects. If an object appears blurred and badly defined, then try an eyepiece with smaller magnification. This way you will achieve a sharper and better defined picture.

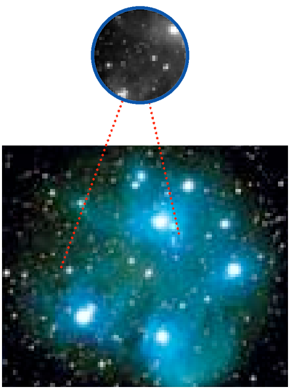


Fig 68: The open star cluster of the Pleiades. Above the section provided by the eyepiece, below the original

4.4.3 Filters

Colour filters are a popular aid during the observation of the moon and planets. They increase the contrast of certain details, which are seen poorly or not at all without filters. In principle there are two problems with observation: (a) Blooming, whereby the border between two areas of an observed object are of different brightness and fray or simply blurr, because the eye is overtaxed by the contrast with high levels of brightness; (b) adjacent areas have similar colouring, but only small differences in intensity. Both effects result in the fact that the combination of eye and brain can no longer separate the two details and consequently try to present both objects as one, which is naturally unwanted.

In both cases colour filters help. In the first case filters help by reducing the brightness of the quantity of light reaching the eye and the object can then be seen better. In the second case, by using filters of a certain colour which strengthens some of the detail and at the same time weakens the rest, so that the contrast between both details increases and the detail can be recognised. The use of the correct colour filter determines whether a point of detail can be seen or not; whether for example you can see three or five eddies in Jupiter's atmosphäre. Dependant on the atmospheric conditions both on earth and on the planet which you observe, filters can make an enormous difference!

Fig 69: With observations of the moon and the planets different filters are fitted.

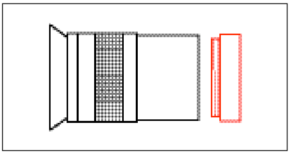


Fig 70: All filters have an eyepiece thread and are simply screwed into the lower end of the eyepiece.

4.4.4 Photographic accessories

A telescope cannot only be used for observing landscapes and the sky. Depending upon the model and equipment it can be transformed also into a tele objective for your reflex camera. With this arrangement you can record your visual images photographically. There is a wide range of useful accessories for the different telescope types, which you can attach to your telescope and transform it into a high performance telephoto camera.

In astrophotography above everything two things are important:
a) extremely precise focusing
b) precise and vibration-free adjustment

Adapters for connecting mirror reflex cameras to the telescope, are available for most telescopes series. Here the camera without the objective, is attached to the so- called primary focus of the telescope. In this way the telescope works as the telephoto objective.

With the DS series it must be noted that, with the altazimuth mounts, no exposure times of longer than approx. 1 minute are possible, otherwise a noticeable image field rotation arises. For short exposures of planets this azimuth mount is still quite suitable. This can be avoided by a polar adaptation using the polar altitude cradle.

If available, the advance mirror locking solution should be activated, in order to avoid vibration of the telescope when operating the release.

For the exposure itself: with bright and large objects like such as the moon, the exposure mechanism of the camera can be used. With deep sky objects such as galaxies, nebulae etc. the light values are far too small; here one must expose for several minutes with a sensitivity starting at 400 ASP. Digital cameras are of advantage here, they are substantially more sensitive compared to miniature film cameras. In addition, the sharpness can be assessed and adjusted better due to the built-in display.

Important:
Since even minimum adjustments during the exposure ruin the photo (the stars appear as twisted lines), it is important to stress that the telescope should be set up as precisely as possible. With parallax mounting (model with pole altitude cradle) the arrangements need to be checked several times and corrected if necessary, before taking the photograph.

Photo adapter for mirror reflex camerass: You simply screw and fasten this adapter to the rear end of the parallax mounting and attach the camera-specific T2-Ring (optionally available).

4.4.5 Other accessories

2x Barlow lens (1 1/4"): This Barlow lens doubles the performance of each eyepiece whilst maintaining good correction of the image field. A 9mm eyepiece results in a magnification of 78x in a lens telescope with 700mm

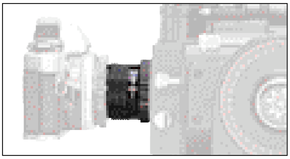


Fig 71: A SLR-camera is connected to the telescope's photo connection by means of the photo adapter

Fig 72: An analogue SLR-camera is connected to the eyepiece aperture by means of projection and focal adapter

Fig 73: A SLR-camera with cable release.

Fig 74: Barlow lens

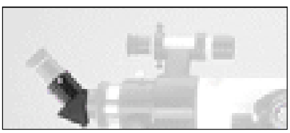


Fig 75: Amici prism

focal length; together with the Barlow lens it delivers the same as the 156x eyepiece.

45° Amici prism: The zenith mirror of a lens telescope sets up the orientation of the image, however it leaves it inverse. For terrestrial applications it is desirable to have a completely, correctly orientated picture. This is reached with the Amici prism, which offers a comfortable 45°-sighting and is fitted into the telescope just like a normal $1^1/_4$" zenith prism into the $1^1/_4$" eyepiece holder.

5. Quick entry

5.1 Which telescope for which job?

Basically the following can be said: No binoculars, Spotting scope or telescope can do everything. You must bear in mind the following considerations in order to find the correct telescope:

- Is it primarily for photography or visual observation?
- Would I prefer to observe the moon and planets, or also deep sky objects such as galaxies etc.?
- Must the equipment be capable of being easily transported?
- How much money to be invested altogether?

If a telescope is to be used for photography, then a stable mount is required, in which the tube motor can adjust the object in each case.

For the observation of faint objects ("deep sky") one needs primarily a large aperture, which can collect much light. For this Newton telescopes are suited, for they offer large apertures at a reasonable price.

In the case of mainly taking observations then the relatively bright planets means it makes sense to have a telescope sense, which offers a good contrast activity – this can be achieved very well with refractors and Maksutov telescopes.
In principle one should not stress this point too much, for a refractor can be used to observe deep sky and for a reflector also to observe the planets.

Easy transportability is important, if one lives in a densely populated area, in which there is much light in the sky at night. If you have to always carry heavy equipment to the car, in order to be able to observe a good sky out in the countryside, soon the pleasure of the hobby will be lost.

Finally the price factor must also be considered. Usually, as you gain experience so your requirements increase and you will want to add useful accessories, such as additional eyepieces and filters or camera adapters, for example. With a limited budget it is therefore sensible to choose a smaller telescope in order to have money left over for purchasing accessories. One exception is astrophotography. Here one should invest from the outset in a stable mounting system. Weak stands which are sensitive to wind and inaccurate adjustments will ruin every photograph and rapidly spoil the joy of astrophotography.

6. Useful tables

6.1 Tables for the geographical latitude of all the larger metropolitan cities

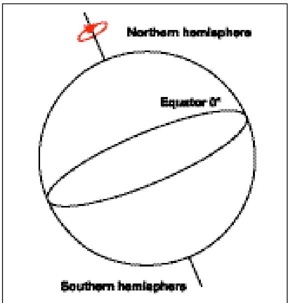


Fig 73: Schematic view of the coordinate system

In order to carry out the procedures for the adjustment of the telescope onto the celestial pole, the degrees of latitude of various metropolitan cities are given in the table below. If you wish to determine the geographical latitude of an observation site and its degree of latitude is not listed in the table, then first select a city, which is close to you. Then, for example, you can visit data bases or web pages in the internet, such as for instance www.heavens-above.com, or you can proceed in accordance with the following method:

6.1.1 Observers in the northern earth hemisphere (N):

If your observation site is further north than the specified city , add one degree of latitude for each 110Kms. If your observation place lies further south than the specified city, then you should subtract a degree of latitude for each 110km.

6.1.2 Observers in the southern earth hemisphere (S):

If your observation site is further north than the specified city is, subtract one degree for each110Kms. If your observation place lies further south than the specified city, then add a degree of latitude for each110Kms.

EUROPE

City	Country	Latitude
Amsterdam	Netherlands	52° N
Athens	Greece	38° N
Berlin	Germany	53° N
Bern	Switzerland	47° N
Bonn	Germany	51° N
Bremen	Germany	53° N
Dresden	Germany	51° N
Dublin	Ireland	53° N
Düsseldorf	Germany	51° N
Flensburg	Germany	55° N
Frankfurt/M.	Germany	50° N
Freiburg	Germany	48° N
Glasgow	Scotland	56° N
Graz	Austria	47° N
Halle	Germany	52° N
Hamburg	Germany	54° N
Hannover	Germany	52° N
Helsinki	Finland	61° N
Koblenz	Germany	50° N
Cologne	Germany	51° N
Copenhagen	Denmark	56° N
Leipzig	Germany	51° N
Linz	Austria	48° N
Lisbon	Portugal	39° N
London	Great Britain	52° N
Madrid	Spain	40° N
Magdeburg	Germany	52° N
Munich	Germany	48° N
Nuremberg	Germany	49° N
Oslo	Norway	60° N
Paris	France	49° N
Rome	Italy	42° N
Saarbrücken	Germany	49° N

Salzburg	Austria	49° N
Stockholm	Sweden	59° N
Stuttgart	Germany	49° N
Warsaw	Poland	52° N
Vienna	Austria	48° N

UNITED STATES OF AMERICA

City	State	Latitude
Albuquerque	New Mexico	35° N
Anchorage	Alaska	61° N
Atlanta	Georgia	34° N
Boston	Massachusetts	42° N
Chicago	Illinois	42° N
Cleveland	Ohio	41° N
Dallas	Texas	33° N
Denver	Colorado	40° N
Detroit	Michigan	42° N
Honolulu	Hawaii	21° N
Jackson	Mississippi	32° N
Kansas City	Missouri	39° N
Las Vegas	Nevada	36° N
Little Rock	Arkansas	35° N
Los Angeles	California	34° N
Miami	Florida	26° N
Milwaukee	Wisconsin	43° N
Nashville	Tennessee	36° N
New Orleans	Louisiana	30° N
New York	New York	41° N
Oklahoma City	Oklahoma	35° N
Philadelphia	Pennsylvania	40° N
Phoenix	Arizona	33° N
Portland	Oregon	46° N
Richmond	Virginia	38° N
Salt Lake City	Utah	41° N
San Antonio	Texas	29° N
San Diego	California	33° N
San Francisco	California	38° N
Seattle	Washington	48° N
Washington	District of Columbia	39° N
Wichita	Kansas	38° N

SOUTH AMERICA

City	Country	Latitude
Asuncion	Paraguay	25° S
Brasilia	Brazil	24° S
Buenos Aires	Argentina	35° S
Montevideo	Uruguay	35° S
Santiago	Chile	35° S

ASIA

City	Country	Latitude
Peking	China	40° N
Seoul	South Korea	37° N
Taipei	Taiwan	25° N
Tokyo	Japan	36° N
Victoria	Hongkong	23° N

AFRICA

City	Country	Latitude
Cairo	Egypt	30° N
Cape Town	South Africa	34° S
Rabat	Marocco	34° N
Tunis	Tunisia	37° N
Windhoek	Namibia	23° S

AUSTRALIA		
City	**Country**	**Latitude**
Adelaide	South Australia	35° S
Alice Springs	Northern Territory	24° S
Brisbane	Queensland	27° S
Canberra	New South Wales	35° S
Hobart	Tasmanien	43° S
Melbourne	Victoria	38° S
Perth	West Australia	32° S
Sydney	New South Wales	34° S

6.2 Table of prominent stars

In the following you find a listing of bright of stars with their coordinates in RA and DEC, in addition the seasons of the northern hemisphere of the earth are shown, when these are particularly conspicuous in the night sky. This list will help you to find suitable guiding stars for the different seasons. If, for example, you are experiencing a high summer evening in the northern hemisphere, then Deneb in the constellation of the Swan would offer itself as an excellent guiding star. Betelgeuse is not suitable in this case as guiding star, because it belongs to the winter constellation of Orion and at this time is below the horizon.

Season	Name of Star	Constellation	RA	DEC
Spring	Arcturus	Bootes	14 h 16 m	+19° 11´
Spring	Regulus	Leo	10 h 09 m	+11° 57´
Spring	Spica	Virgo	13 h 25 m	-11° 10´
Summer	Vega	Lyre	18 h 37 m	+38° 47´
Summer	Deneb	Swan	20 h 41 m	+45° 17´
Summer	Atair	Eagle	19 h 51 m	+08° 52´
Summer	Antares	Scorpion	16 h 30 m	-26° 26´
Autumn	Markab	Pegasus	23 h 05 m	+15° 14´
Autumn	Fomalhaut	Southern Pisces	22 h 58 m	-29° 36´
Autumn	Mira	Cetus	02 h 19 m	-02° 58´
Winter	Rigel	Orion	05 h 15 m	-08° 12´
Winter	Beteigeuze	Orion	05 h 55 m	+07° 25´
Winter	Sirius	Great Dog	06 h 45 m	-16° 43´
Winter	Aldebaran	Taurus	04 h 35 m	+16° 31´

6.3 Distances in the universe

In the universe there are infinite distances! Storytellers of well-known science fiction series already know that. Others will find it impossible to imagine just how far “far” actually is. With a quick overview we would like to give an impression of the distances involved in the universe.

Measurable in Kilometres (Kms): The distance between the Earth and the Moon amounts to about the same distance that a good car would cover in its very intensive lifetime , i.e. on average 383,000 km.

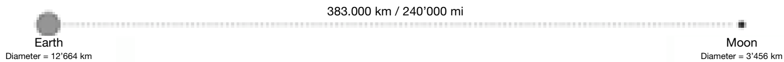
Measurable in astronomical units (AU): The distance from the earth to the sun amounts to a AU, one “astronomical unit “. These are 149 million

6. Useful tables - Distances in the universe

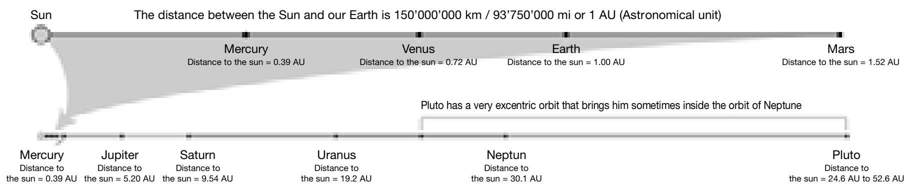
Kms. The AU serves particularly as the unit for distances within the solar system. The last planet of our solar system Pluto is about 40 AU from us.

Measurable in light years (ly): One light-year is the distance that light travels in one year in the vacuum of the universe. That is 9.46 x 1015 m = 9.460.000.000.000 (9.46 trillion) Kms. Or 63,490 AU. We now leave our solar system and look at the nearest star Alpha Centauri which can only be seen from the Southern Hemisphere. This is 4.3 light-years distant from us. This distance is so enormous that, in a model, in which the earth would be 25mm from the sun, the distance to the next star would amount to over 6,5km!

Distance between Earth and Moon

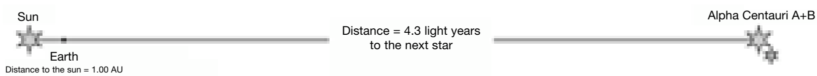


Distance between Planets



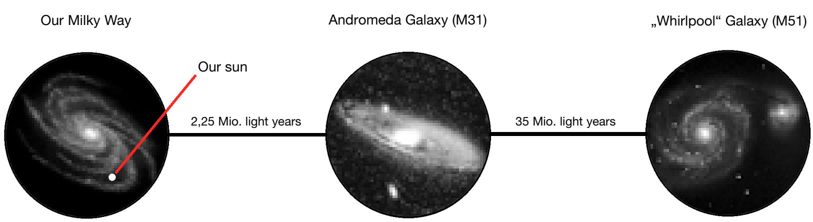
Distance between Stars

The distance between our Sun and the nearest star is about 4.3 light years or approx 40 Billion km. This distance is so enormeous, that in a model where our Earth is 25 mm (1 inch) distant from the sun, the distance to the next star would be 6.5 km/4 mi!



Our home galaxy, the Milky Way, inhabits round about 100'000'000'000 stars. With its spiral arms, it has a diameter of about 100'000 light years.

Distance between galaxies



7. Glossary

The following glossary contains a compilation of the most important terms, which lead again and again to misunderstandings by beginners. It contains the terms used most frequently and these will also be used in this training booklet.

A

Achromatic: Non-chromatic, non-coloured; Name for a lens combination, which can adjust the most important colour defects. With high magnification one can recognize so-called secondary colour defects in achromatic objectives.

Amici prism: (Diagonal prism) An Amici prism causes an upright and side corrected image reflection in an astronomical telescope. Pre-supposing, no further optical system (inverter lens or zenith reflector) is used in the telescope at the same time.

Aperture: Opening (of a telescope).

Aphelion: The point in the orbit of a planetary object, furthest in distance from the sun.

Arc minute: This is what one uses in the sky, in order to find objects more easily. It is a sixtieth of an angular degree) (e.g. a ten-cent piece seen from a distance of 68 meters . Symbol: '

Arc second: This is an angular measurement. It is a sixtieth of an arc minute. If one turns once in a circle, that is 360°. Thus 1° corresponds to 60 arc minutes (60 '), which are divided again into 60 arc seconds (60 "). To give an example - one arc second corresponds to the distance between two headlights seen from the distance London to Birmingham.

Aspherical: Not spherical, not shaped like a sphere.

Asteroid: One of many thousand small celestial bodies, which circle the sun. Often called a small planet.

Astronomical unit: (AU) 1.49 x1011 metre, corresponds to the average distance from the earth to the sun.

Autocollimation: Test and adjustment procedure, with which a ray of light is passed twice through the optical system, so that errors appear to be twice as large than they are in reality.

Altazimuthal mount: Adjustment of an astronomical mount in the horizontal/vertical direction (“Right Ascension “- axis is parallel to the direction of the force of gravity and points to the zenith).

B

Barlow lens: Increases the **focal length** of the objective by a certain factor and increases the magnification accordingly. (the factor 2x or 3x is usual)

BK-7: Type of optical glass with special properties (transmission, refractive index) for optical applications

C

Chromatic aberration: Colour defect of a lens..

Coating: Treating of a lens or a mirror, by which the transmission and/or the reflection of the light and the resistance to cleaning are increased at the same time.

Comet: Small objects from the cloud of debris at the edge of the solar system, which often circle the sun on very strong elliptical paths

Contrast: Relationship of the light intensities of two neighbouring areas.

Conjunction: Time that two objects are positioned next to each other.

Cross hair eyepiece: Eyepiece with cross hairs in the centre. Modern designs have an etched glass plate, on which double cross hairs are etched. The star being observed is not covered by the square created in the centre.

D

Dark adaptation: Ability of the eye to adjust itself to darkness whereby its sensitivity is increased. Dark adaptation requires about 20-30 minutes rest without bright sources of light and is disturbed by white light. Therefore red light is used, which disturbs the dark adaptation only slightly during night-time astronomy.

DC servo motor: Direct current motor with position control and favourable characteristics for computer control.

DEC: short for „**declination**" .

Declination (DEC): One of the celestial coordinates. It describes the angular distance of a celestial object north (+) or south (-) the celestial equator. The declination corresponds to the geographical latitude, if one were to project the Earth's coordinate grid onto the sky.

Deep sky: All celestial objects, outside our solar system are called deep sky objects (galaxies, star clusters, nebula,…).

Degree: Angular unit (e.g. a ten-cent piece seen from a distance of 1.13 meters). Abbreviation: °..

Dissolution: Separation ability either in the sense of better recognition of detail (angular resolution) or particularly with CCD astronomy in the sense of the separation of different stages (dynamic dissolution).

Double pass laser autocollimator: Double run laser autocollimator, see „**autocollimation**" .

Dying-down time: Time interval, which is required for an instrument to settle down again after its mount has been heavily hit.

E

Ecliptic: The ecliptic corresponds more or less to the circular path, on which the Earth moves around the sun. This also determines the sun's passage across the sky. In addition the planets of our solar system follow a path relatively close to the ecliptic. The term ecliptic (from the Greek) means blackout. The reason lies in the fact that the moon and sun become dark only if the full or new moon are on the on the ecliptic.

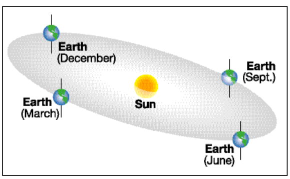


Fig 76: The ecliptic is the path of the Earth

Equatorial mount: (**Parallax** mount) Adjustment of an astronomical instrument onto the celestial pole (Right Ascension axis is parallel to the Earth's axis).

Equinox: The day on which the sun can be seen exactly for half a day. There is a spring equalise on March 21st and an autumn equalise on September 23rd respectively. On this day the sun goes through one of the intersections between the **ecliptic** and the celestial equator, spring or Autumn point.

Extension area: Range from the maximum to the minimum useful magnification of a telescope; should be equipped ideally with 5 to 6 eyepieces and distributed as evenly as possible.

F

Focal length: Distance objective lens or main reflector to the focal point. Magnification is calculated from the focal length of the telescope and the eyepiece using the formula focal length of the telescope in mm/focal length of the eyepiece in mm.

Focal point photography: Photography in the focus of the telescope without the eyepiece..

Focaltest: Optical test for determining the accuracy of a reflector.

Focussing: Focus

Frequency converter: Equipment, which is needed with telescope drives with synchronous motor for the influence of the engine speed.

G

German mount: **Equatorial** (**parallax**) mounting with the German coordinate system. This type of setup is becoming extremely popular world-wide. It was introduced for the first time many years ago in Germany.

GO TO: Function for the automatic localization and positioning of a celestial object with hand computers for telescopes.

GPS: Global Positioning System: This system serves to determine the observation location, the date and the time. This American system uses satellites in the Earth's orbit.

H / I

Heavy Duty: Particularly solid and stable construction.

Height: Distance of an object above the horizon, measured in degrees, minutes and seconds . Positive values show that the object stands over the horizon, negative that the object lies below the horizon.

Image field de-rotator: Instrument, which compensates for image field rotation, by precisely the image field in reverse.

Image field rotation: Rotation of the picture in the telescope, when the equatorial set up is not carried out precisely (in particular with the azimuth set up).

Inch: 1 " = 25,4mm.

Initialisation: Initial calibration of a telescope.

Interference filter: Filter, which consists of several ,individual layers of a special material with a thickness of only 1/4 wavelength, which determine the permeability of light, in a narrow spectral (colour) range.

Intersection function: Exact positioning method with the help of two or three reference stars, which can be observed in the proximity of the object.

K / L

Kellner eyepiece: Tripple lens eyepiece with good image according to Kellner

Light collecting ability: Ability to collect and combine light from an entire surface at the focal point. With reflector telescopes with a secondary mirror in the light ray path, its surface must be chosen for its ability to collect light.

Light transmission: Light permeability

M

Magnitude: The brightness of a star visible in a telescope or with the naked eye.

Fig 78. One of the best-known Messier objects: The Pleiades, Messier 45 – M45(myth: Daughters of Atlas)

Main reflector focusing: Focusing by moving the main reflector back and forth in the tube, as opposed to focusing by means of the eyepiece. It has the advantage that there are no moveable mechanical parts on the outside of the telescope and focusing path for many accessories remains short.
Maksutov: A reflecting telescope with particularly good image properties when little contrast is present.
Messier objects: 110 nebula objects (**deep sky** objects), compiled in the 18th Century by the French astronomer Charles Messier (1730 to 1817)..
Micro slewing: Micro-fine procedure for a telescope drive for precise positioning.

N

Night display: Back-lit, red display of the hand control box (important for the preservation of the **dark adaptation**).
Nadir: The point in the sky, opposite to the zenith, therefore directly beneath the observer.
Zero test: Optical test, with which the quality of the overall system is judged on the basis of producing a smooth, even surface. This is gauged as "optical zeroing ".

O

Object library: List of celestial objects, which is stored in the electronics of the telescope.
Obstruction: Shading
Opening: Aperture
Aperture ratio: Relationship between the aperture and **focal length** of the telescope.
Aperture number: Relationship of the focal length to the aperture of a telescope..
Eyepiece: A type of magnifying glass for magnifying the image produced by an objective.
Eyepiece focusing ring: An adjustable mechanism on the telescope to focussing it.
Orthoscopic eyepiece Eyepiece with four lenses for improving colour correction such as **Kellner eyepieces.**

P

Parallactic: Equatorial.
Parallax: The apparent change in the position of an object in the sky throughout the year. Due to the different positions of the Earth on its orbit around the sun close objects appear to wobble. The same effect can be achieved if an observer looks at an object close to and first closes the left eye and then the right.
Parsec: The distance from the earth that an object must have to have parallax of a one arc second. Corresponds to approximately 3.26 light-years.
Periapsis: The point in the orbit of an object, when it is next to the sun.
Planet: One of the large, well-known celestial bodies, which circle the sun. Descends from the Greek word for Wanderer.
Planetary nebula: A planetary nebula is formed, if a sun, which has a max. of 1.4 times the mass of our sun dies. The outer layers are rejected and usually form ring-shaped nebulae. The term "planetary nebula" is derived

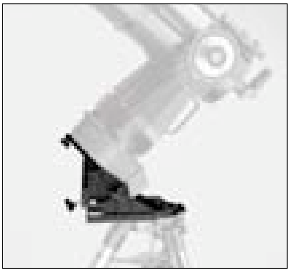


Fig 79: This telescope with azimuth fork mounting is mounted onto a pole elevator cradle.

from the fact that in small telescopes they look like planets i.e. disk-shaped.

Plössl eyepiece: Refined orthoscopic eyepiece with large visual field and improved edge clarity and colour correction.

Polarisation filter Neutral filter, which deals with the weakening of light by polarization.

Polar wedge: Mechanism, which tilts the drive of a telescope by an angle from the horizontal corresponding to the geographical latitude of the place where the instrument is located, so that the RA axis is parallel to the Earth's axis andallows for compensation of the rotation of the Earth by means of only one axis.

Power panel: Instrument panel of the telescope drive.

Precession: A very slow oscillating motion of the Earth's axis, which is triggered by the gravitation forces of the moon.

Projection photography: Photography by means of an intermediate eyepiece, whereby the effective magnification increases.

Pulse-drive: Special mode, with which the reticle of an eyepiece receives tension for short instances, so that fainter stars can be followed, which would otherwise receive too much illumination due to the brightness of the reticle.

Q / R

Quarz-control: The accurate frequency is given by a quartz, which is necessary for adjusting to the star speed.

RA (axis): Short for „**Right Ascension**".

Reference stars: For the initialization of a telescope with computer control, a reference star list of all bright stars and also stars further away, can be used.

Reflector: Reflector telescope (light reflection by reflector). See the diagram on page 45.

Refractor: Lens telescope (Light refraction = refraction of light through the lens). See the diagram on page 45

Right Ascension (RA): Corresponds to the geographical longitude, if one were to project the earth's coordinate grid on to the sky. The Right Ascension axis of a parallactic or equatorial mount is pointed to the celestial pole and is aligned parallel to the Earth's axis. It can be driven by means of an axle or by a **tracking motor**. With this adjustment the Earth's rotation is compensated for and, once adjusted, the star remains in the field of vision of the telescope. The RA axis is also known as the polar axis.

Ronchi test: Optical test for the examination of the accuracy of a reflector's surface.

RS-232: Interface to and from personnel computers for communication with external devices (e.g. telescope) or communicating amongst themselves.

Fig 80: Schmidt-Cassegrain telescope

S

Schmidt (corrector) plate: Correction lens with both sides having an **aspherical** polish in a **Schmidt Cassegrain telescope.**

Schmidt-Cassegrain telescope: Combination of a Cassegrain telescope with the idea of a Schmidt camera. Combination of the advantages of both systems whilst avoiding the disadvantages of both.

Fig. 81: Schmidt-Newton telescope

Schmidt-Newton telescope: Combination of a Newton telescope with the idea of a Schmidt camera. Combination of the advantages of both systems whilst avoiding their individual disadvantages.

Seeing: Conditions of visibility.

Siderial speed: See **star speed.**

Sky tour: A tour of the sky limited at the wishes of the user, where one object after the other is automatically observed.

SmartDrive: Reconciliation of the periodic worm conveyer error (English: PEC).

Spotting Scope: Telescope for terrestrial applications.

Star speed: Speed of the stars in the telescope, if this is not adjusted. Produced by the earth 's rotation. Scattered light screens prevent scattered light in telescopes and optimize thereby the **contrast.**

T

T-mount: Adapter ring between a mirror reflex camera and the universal T-thread (M42 x 0,. 5mm), with focal and projection adapters as well as the off Axis Guider end.

Tracking motor: The tracking motor can only be used with **equatorial** mounts. It is fitted to the **Right ascension axis** and compensates for the movement of the earth. A tracking motor is absolutely essential for astrophotography.

V - Z

Viewfinder / Spotter scope: Smaller telescope, which serves for manually observing objects.

White dwarf: A white dwarf is the collapsed core of a sun, which had a maximum of 1.4 times the solar mass. The outer layers were rejected and form a so-called **planetary nebula**. The White Dwarf is about as large as the Earth, but weighs about as much as our sun.

Zenith / diagonal prism: Reflector with 90°-deflection, which facilitates viewing objects close to the zenith.

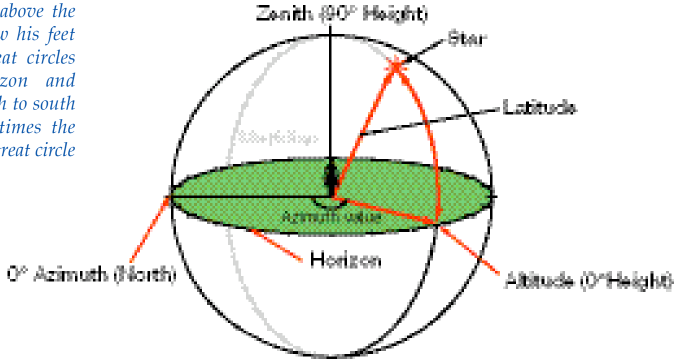
Zenith / diagonal mirror: Mirror with 90°-deflection, which facilitates the viewing objects close to the zenith.

Fig. 82: Diagonal prism and mirror

Coordinates when using an altazimuth mount

Horizon system

Fig 83: Horizon system: A vivid coordinate system. The observer is the central point of the celestial sphere, the pole lies above the observers head (zenith) and below his feet (nadir). The most important great circles (mathematically) are the horizon and meridian. Thus, the line from north to south through zenith and nadir. Sometimes the term prime vertical is used for the great circle through east and west.



Coordinates when using an parallax mount

Equatorial system

Fig. 84: Right ascension "alpha", angle between the vernal equinox and the heaven equator intersection. It is measured from the vernal equinox against the daily motion of the celestial sphere in measure units from 0h to 24h.

For example: Sirius has a right ascension = 6h 45m 9s, therefore it lies approximately 90° (=6h) east of the vernal equinox on the celestial sphere.

Declination "delta", angular spacing between stars and the celestial equator, on the star's declination circle counted positive going north and negative going south.

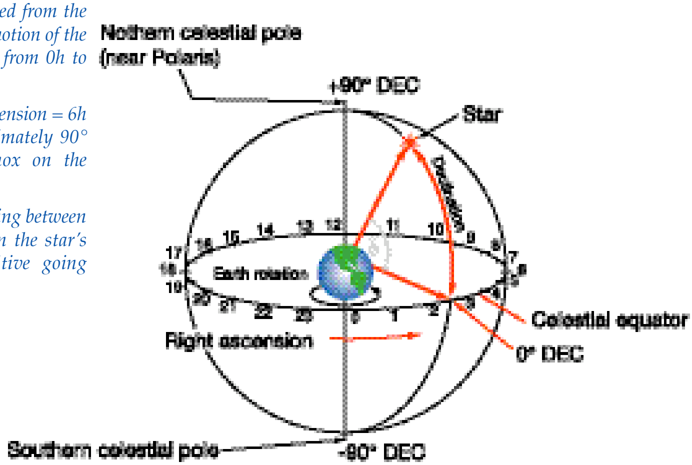


Table 3 - Eyepieces' fields of view

	f/20 mm	f/12 mm	f/4 mm

Fig. 85
Moon

Fig. 86
Orion nebula

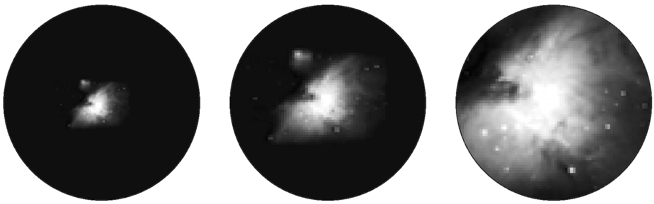


Fig. 87
Ring nebula

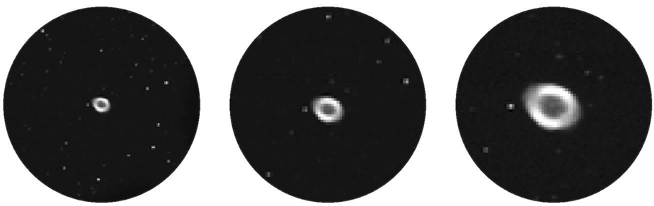


Fig. 88
Dumbbell nebula

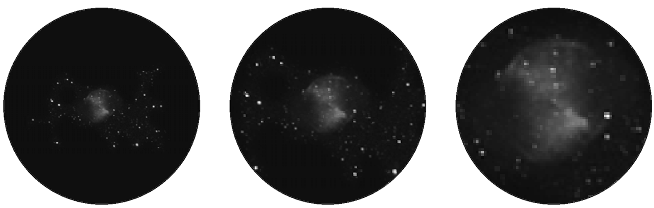


Fig. 85-88: The images show eyepiece field of views for telescopes with approximately 700 mm focal lengths.