# Telescope selection guide

**by Dr Jürgen Schmoll**

Maybe you are new to astronomy. After reading some books and visiting a public observatory you decided it is time to get a telescope yourself. Perhaps you intend to get a telescope for a loved one. Your partner. Your child. In any of these cases, you may appreciate some guidance to assure the telescope you decide on fulfils the expectations.

## About telescopes

Telescopes have been invented in the early 1600s. Since then, many variations of them hit the scenes, either improving on size and quality, or specialising into certain aspects of observations.

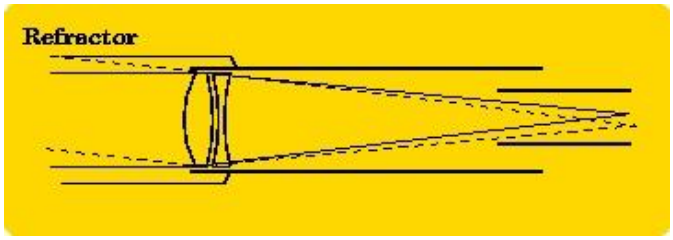
An astronomical telescope has various aspects that differ from telescopes intended for earth observations (like spotting scopes for bird watching):

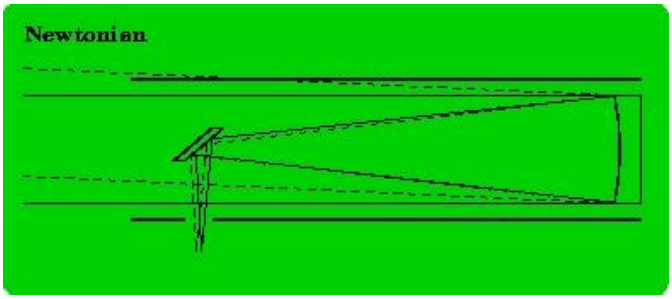
- The astronomical telescope is an open system. You can change eyepieces to adapt the magnification to your object. Small, bright objects are observed with higher magnification than faint, large ones. Other accessories can be added quickly, for example a diagonal to access the eyepiece easier when the telescope points upwards, or filters to get more contrast on gaseous nebulae. Even a camera can be attached to try photographs through the telescope.
- While a spotting scope intended for bird watching will show the bird upright and in correct orientation, astronomical telescopes do not include an optical system to erect the image. In space, up or down does not matter and the additional prisms or lenses would just consume precious light. However, such systems can be purchased to make an astronomical telescope fit for looking at terrestrial objects as well.
- Astronomical telescopes are large and powerful. They cannot be held by hand, but come on a stand. Usually they stand on a pier or tripod, with a connecting bit that allows to turn the telescope to an object and lock it there. This connecting part is called the mount. As the Earth is rotating, the objects will drift out of the field of view and the observer has to follow the object. Simple alt-azimuth mounts have to be moved horizontally and vertically to follow, while more elaborate equatorial mounts are aligned to the Earth axis. A single rotation with a slow motion control, or even a motor, will be sufficient to follow an object with ease. A stable and precise mount is as important as the telescope itself !

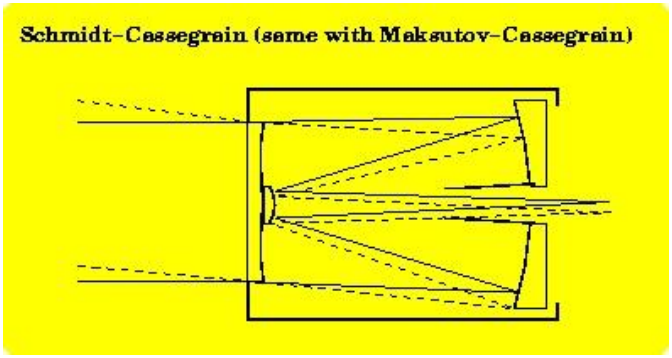
A complete astronomical telescope comes with a tripod, a mount and several lenses. In addition to that there may be a smaller finder scope mounted on the main tube to help to aim for an object. This finder scope is either a small telescope itself, or a red dot finder. Apart from eyepieces to achieve different magnifications, some additional accessories may be included, as filters or a Barlow lens that increases the focal length of the telescope and hence it’s magnification.

**Refractors and reflectors**

Telescopes come in two different “flavours”. Either they use lenses to focus an image, in which case they are called refractors. Or they use mirrors instead – reflectors.




Top: In a refractor, a lens system focuses the light.

Middle: The Newtonian reflector uses a mirror to focus the light. A second, small mirror places the focus to the side of the top end of the tube, where the eyepiece is located.

Bottom: In Cassegrain-style instruments two mirrors reflect the light to a focus located behind the primary mirror that has a central hole.

Each of the designs has certain advantages. The refractor is easy to keep as optics does not get misaligned easily. There is no secondary mirror in the beam path that gives rise to diffraction effects in the image. However, large refractors tend to be long and cumbersome. Also they are getting quite expensive. They show a small amount of false colour (colour fringing, or in shoptalk “chromatic aberration”). There are even more expensive telescopes out with specially designed lenses to suppress the colour fringing so it is not notable. Those telescopes are called apochromatic.

The Newtonian reflector is very popular amongst amateurs. For a given budget, usually a Newtonian offers the most in terms of aperture. As more aperture an instrument has, as more light will be collected what helps to see those dim, faint objects beyond our solar system. However, observers have to get used to the eyepiece position that is near the top end of the tube. Reflectors use glass mirrors with a very thin layer of aluminium evaporated onto them, and after many years this layer may have to be replaced.

The Cassegrain telescope and it's varieties (like Schmidt-Cassegrain or Maksutov-Cassegrain) feature a short focal length primary mirror. The light from there intercepts a secondary mirror that is convex (bent outwards). This mirror relays the focus behind the primary mirror (which is perforated so the light gets through), so looking through such a telescope is similar like looking through a refractor. The focal length of such systems is relatively high, so higher magnifications can be achieved. On the same token, these telescopes are very compact: 2m focal length can be hidden in a 40cm short tube!

**Magnification**

Here is where the trouble starts! Many cheap telescopes offer an incredible amount of magnification. For example, a 60mm refractor for less than 100 pounds features 675x magnification! Fact is, while this magnification can be reached, there is no use of it. A rule of thumb for a maximum magnification says that this value is reached at two times the diameter of a telescope in millimetres. So, the 60mm refractor can provide only about 120x before the image gets too blurry and dark. Sadly, 675x sells better and it indicates that the accessories that come with the scope are not been selected in a sensible way.

With a 150mm reflector for example, the maximum magnification is 300x. But even this depends on the object, as many objects look clearer with lower magnification. Usually the moon and planets are the objects where the maximum magnification can be used best. This is true only when the atmosphere collaborates. In nights where the stars twinkle, the planet images may look like seen from under water and less magnification shows them better.

**Example: A 50mm refractor**

For decades, such instruments were the default beginner's scopes. They feature a small refractor of 50-60mm aperture, some eyepieces, a diagonal and a small finder scope. They come on alt-azimuth mounts that allow to move them about but to follow an object, both axes have to be used.

Such an instrument will show the brightest nebulae like the Great Orion Nebula, many open star clusters like the Pleiades, a few galaxies and in our solar system they show the craters on the moon, the cloud stripes and moon of Jupiter and Saturn's rings.

Sadly, in recent years manufactures cut corners. Many parts of contemporary instruments of this kind are plastics, so the telescope is mechanically not sound any more. Usually they come with Huygens-style eyepieces which are of the cheapest kind. On the plus side, they can be a cheap taster to check if astronomy is the right hobby or not.

**Example: A 200mm Newtonian on an equatorial mount**

This telescope is a 200mm Newtonian on a sturdy equatorial mount. In this version, it is already a bit big for a beginner's scope, but it shows several advantages. The mount is sturdy and driven by motors so it follows an object. This instrument can be used to make photographs of faint objects as well, as the tracking accuracy of the mount is good enough. Visually, such a scope shows what the small refractor does, but in much more clarity and instead of the brightest nebulae and galaxies only it shows a large range of them. Globular clusters like M13 in Hercules do not show up as a faint fuzz like in the 50mm instrument but they can be resolved into single stars.

**Is this telescope the right choice for me / him / her ?**

That is another tricky question. The choice of a telescope is not straight-cut, but rather a decision process like for a musical instrument. Guitar or trumpet, a piano or rather singing classes – it all depends on various factors and interests. In case of astronomy, there are these parameters to consider:

- **Budget**: Astronomical telescopes can costs 10 or 1000 pounds. Clearly, the "you get what you pay for" mechanism applies here. While it is advisable to start not too cheap, it is not necessary to spend a fortune especially if you do not know yet if the interest in astronomy will hold on.
- **Particular interest**: The newcomer may have been hooked by seeing Saturn through a telescope in a public observatory, and his main interest be planets. Or really distant objects like nebulae and galaxies. There are so many different things in the sky which a telescope can be optimised towards to.
- **Observing technique**: Is it planned to look through or is there a desire to add a camera later to image the sky ? For imaging, an equatorial mount is necessary while the pure visual observer can get along with an alt-aximuth mount.
- **Location** – is there a dark garden where a heavy telescope can be rolled out to, or is it necessary to escape a light polluted city by car ? This will influence the portability you require for your telescope. While in principle a bigger telescope is better than a smaller one (if the quality is the same), a large telescope does not help when it does not get used because it is too cumbersome to dismantle and re-erect outside of the town.
- **Personal choice**: Is the new telescope owner a haptic person who likes to push a telescope around using star maps to find the objects ? Or is the telescope rather for a "geek" who loves GPS and computer control ? Can the telescope easily be handled by the new owner – this is particular important for children.
- **Taste**: Even with telescopes are to be looked through rather than looked at, the question which scope to get may be influenced by taste as well. It is just important to remember that a nice design is not important when using it at night.

One word about computerised telescopes: There are many so-called "GOTO" instruments out there, where the objects are being found by a computer once the telescope has been initially set up. Opinions about these telescopes differ. On the pro side, you can find objects easier as you do not need a star map. However, in the low price sector GOTO means that a significant fraction of the budget is used up by the computer, and there is not much left for the telescope. So you may end up with a telescope data base of thousands of objects, but the telescope being too small to show any but the brightest ones. Also, finding objects yourself is fun and rewarding – and part of a learning process to find your bearings on the skies. The author of these lines has two computer controlled mounts but still prefers to find the objects himself. This is definitely a question of personal choice.

**Where to buy a telescope ?**

There are many places to buy telescopes. Internet sites, department stores, specialised dealers or even some food discount stores have special offers – particular in the run-up to Christmas. However, not all suppliers have the quality needed to assure the start into astronomy does not end up in frustration. When you have a particular instrument in mind, it is very helpful to seek advice by contacting amateur astronomers, e.g. through a planetarium or a public observatory nearby. This could also be the meeting point to look through some of their instruments to get a better idea about what to expect.

It is advisable to have a look at professional dealers who are specialised on astronomy. When you buy a popular astronomy magazine like "Astronomy Now" or "The Sky at Night", you find adverts with web links. The advantage if specialised dealers is that you have a better chance to get good advice, and also a guarantee about the optical quality so you can return the instrument if it turns out to be faulty.

**Got a telescope ! What now … ?**

If you have access to an experienced amateur astronomer or a society, it is advisable to let somebody look through your telescope to check it out. Using star-testing, optical aberrations will show up quickly and the telescope can be adjusted if necessary. Reflectors in particular are not always at their optimum shape after unwrapping all the packaging, but a skilled amateur can put it right quickly and (more important) show you how to do it yourself.

You will probably struggle with the first steps how to use the telescope. It is advisable to start with the lowest magnification to find an object, as the field of view is the largest one. Once you have aligned the finder using a distant object (a church spire for example), you can point the telescope to an object using the finder. Then you use the lowest magnification of the telescope, followed by higher ones if required.

To find nebulae, galaxies and star clusters a star atlas is a very good addition to the telescope. To read the atlas without losing your dark adaptation, get a red light torch. This torch does not have to be bright, and the red light helps to keep your night vision. To find out which constellations are visible when and where, a planisphere is another worthwhile addition. Star atlases and planispheres are available online or in good book stores. Red light torches can be purchased from astronomy places, or make one yourself using a bicycle rear light or a white torch with some red material wrapped around it.

It may take a full night to find your first object, but like playing a musical instrument the experience gained will help to accelerate the progress until you learnt the new skill completely.

Beware – once hooked by the astronomy bug, you may end up like the author of this brochure, having an observatory in the garden with various telescopes for different purposes!

The two equatorially mounted white telescopes on the left are a Cassegrain-style and a Newtonian, used mainly to photograph the heavens. Fixed at the wall there is a long refractor that is nice for moon and planets – mostly used for public observing events. The large pair of binoculars on the tripod is a nice wide field setup that also assists in locating new objects.