WORKING BEFORE OBSERVATIONS

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Abstract

In this workshop we will try to get to know the sky that we can see during this course in Madrid (Spain). The observable sky is different from one place to another depending on its latitude and it is important to take into account the quality of the sky, because the light pollution introduces a lot of problems when observing in Madrid.

CONSTELLATIONS

Astronomers consider eighty-eight constellations that cover the entire sky. Looking at the sky on a clear, dark night, the unaided human eye can detect about 6000 stars. Because half of the sky is below the horizon at any one time, we can see only roughly 3000 stars at most. When ancient peoples looked at these thousands of stars, they imagined that groupings of stars traced out pictures in the sky. Astronomers still refer to these groupings, called constellations (from the Latin for “group of stars”).

Figure 1. Constellation drawings by connecting stars
Figure 2. Greek and Roman mythological constellations

Figure 3. Constellations as they are now defined by IAU
Amateur astronomers usually have a visual image of the constellation as seen in Figure 1 in order to search for celestial objects but ancient people made mythological stories to explain the positions, movements and changes in the stars. The characters of the stories can be imagined creating an image around the related stars as seen in Figure 2.

In modern astronomy constellations are only regions in the sky delimited by lines of right ascension and declination. The boundaries of the constellations are listed by E. Delporte, on behalf of the IAU, in, Delimitation scientifique des constellations (tables et cartes), Cambridge University Press, 1930; they lie along the meridians of right ascension and parallels of declination for the mean equator and equinox of 1875.0. Figure 3 presents an example of the delimitation of the constellations for the same region of the sky presented in Figures 1 and 2.

Firth at all, we should find, approximately, the cardinal points of the place where we are; it is said, to orient geographically. After that, we will try to recognise celestial bodies in the sky. We will begin with the most important constellations recognising them by their imaginary figures. After locating the most significant northern constellations, from these, we will look for some other way to locate and identify other celestial bodies less spectacular and showy that the first ones. Taking into account some alignments as such as Figure 4 we intend to pay a great deal of attention to them during the observation sessions.

Figure 4. The most usual alignments in the Northern hemisphere
PLANISPHERES

A planisphere is an astronomical tool that helps to us to locate and identify celestial bodies in the sky with the naked eye. The planisphere displays the positions of the stars on any day of the year at any time you choose. The planisphere is made with two discs; one of these is the fixed part and the other, the movable one. In the fixed disc we draw graduation (24 hours, months and days and zodiacal constellations), constellations, meridians, parallels, equator and ecliptic. In the movable disc we cut the horizon for the fixed latitude.

To use a planisphere we should proceed using the following steps:

- Rotate the top disc to align today’s date with the time at which you want to observe. The planisphere shows the sky as it will then appear.

- Hold the Planisphere high in front you. The border surrounding the window that we had cut in the movable disc represents the horizon. Turn the entire planisphere so that the direction you’re facing is now at the bottom of the planisphere.

- Compare the map to the sky. The centre of the map shows the stars directly overhead. The larger the star’s symbol on the map, the brighter it appears in the sky.

For example, face to North and hold the Planisphere over your head so that the arrow labelled North is pointing North. Can you find the seven–star pattern called the Ursa Major? Or try Cassiopeia, the five-star pattern that resembles the letter “W”?

We have written above that in the movable disc we cut the horizon for fixed latitude. This means that to different latitudes we need different planispheres because the sky that we can observe, from places located toward the North of the hemisphere, close the tropic of Cancer or near to equator, is also different.

Figure 5. Horizon to people located: a) 40º of latitude, b) in the equator (0º) and c) in the Pole (90º of latitude). It is easy to observe that the sky a top each one of them is different.
BINOCULARS

Binoculars are an ideal instrument for studying the night sky and should be in every astronomer’s arsenal. They have important advantages over telescopes - for example they are cheaper, smaller, easier to use and more versatile. Basically binoculars collect more light than your eyes, making dim objects brighter and giving some magnification. They can reveal planets and moons and give access to all kinds of deep space objects.

**Binocular descriptions** Binoculars bear inscriptions such as ‘10×50’ and ‘7×40’. The first number refers to the magnification (e.g.) 10 or 7 times. The second number gives the diameter of the larger objective lens in millimetres (e.g.) 50 mm or 40 mm, which relates to its light-gathering power.

Recommended sizes for astronomy are 7×50 or 10×50.

**Focusing** First turn the central wheel until the binoculars give their sharpest image (this may be helped by shutting your right eye) then while keeping your left eye shut, gently turn the focusing ring on the right eyepiece until focus is perfect. Stars should appear as tiny pinpoints with both eyes open.

**Defects** If binoculars show rainbow colours around a bright light source, the optics are poor quality. If images like stars appear double with both eyes but single with one eye, they are out of alignment. In either case, do not buy or take back to the seller.

**Binocular shake** One problem of hand-held binoculars is that they magnify the natural muscular movement of your hands and make the stars dance around. To minimise shake, brace your arms or elbows on something solid like a wall or fence.

**Binocular mounts** A mount converts binoculars into an astronomical instrument. A good camera shop will sell you an adaptor that fixes binoculars to a camera tripod. The tripod controls allow you to move and lock the binoculars in position.

**Binoculars and the night sky** Star clusters, nebulae, galaxies, our Moon are ideal subjects for binoculars. They are an excellent gateway to the stars.

**THE MOON**

The Moon is a marvellous object to be observed. Close to the Earth, brilliant, changing every night (and day!) in position and shape, the Moon offers a lot of topics of observations to the beginner in astronomy, but also to the experienced astronomer who wants to know the smallest details on its surface. During this Summer School we shall have the opportunity to observe the path of the Moon across some constellations of the ecliptic, and become familiar with some “seas”, mountains and craters on its surface.

**OBSERVATION OF THE PATH OF THE MOON**

On the map below, we can see the successive positions of the Moon from November 27th to December 1st. Every night it is possible to observe, hour by hour, the movement...
of the Moon in relation to the positions of the nearest stars. And why not make a
drawing of the nearby constellations and the positions of the Moon, and then a
comparison with the map? The Moon’s diameter can be the scale unit.

![Figure 6. The Moon from November 27th to December 1st](image)

OBSERVATION OF THE MOON’S SURFACE

The Figure 7 shows the Moon as a whole. It is near the terminator (the line between
light and darkness) that the craters are the most visible, because the Sunrays are roughly
tangential to the ground and so the shadows of these craters are very prominent. With
every map, we give some information about the most important objects that can be
observed on the corresponding part of the Moon.

There is no water on the Moon, and the “so called seas” are only large flat surfaces of
solidified lava. The craters are, more often than not, impact craters, formed more than 3
000 million years ago from the fall of asteroids and meteorites. Some older craters have
been modified or partly destroyed by more recent impacts. The craters didn’t suffer any
other modifications since their formation because there is no erosion from water or wind
(there is also no atmosphere on the Moon).

By observations you will be able to draw on the map, every night, the position of the
terminator.

Be careful: If you observe the Moon with a telescope, the image will be inverted!
TELESCOPES

A telescope is a relatively complex instrument in which there are several optical parts described by the physics of reflection and refraction, something that is not always known to students and teachers who are not specialists in Astronomy. For that reason we find it opportune to summarise the main concepts of the optics of telescopes and to describe the various types of telescope and their accessories. This activity will be carried out “directly”, in front of various types of telescope and their accessories.

GENERAL NOTES ON TELESCOPES. WHAT IS A TELESCOPE?

A telescope is a device that facilitates the viewing of a distant object, in our case astronomical and therefore effectively located at infinity. Telescopes consist of an
optical system basically made up of two elements: the objective and the eyepiece and of a mechanical structure that supports and protects the optical parts and permits the orientation of the telescope to any desired direction.

The objective is the most important optical part of a telescope as it defines the light-gathering ability of the instrument. Its main purpose is to pick up all the light possible from the object to be observed. The eyepiece magnifies the intermediate image formed at the focus of the lens or mirror objective. The eyepiece is a very precise lens system and can be interchanged with others of various focal lengths to adjust the magnification of the telescope.

The telescopes are, basically, of these three types: a) Refractors, b) Reflectors and c) Mixed lens and mirror systems (Schmidt-Cassegrain and Maksutov-Cassegrain).

For teaching and amateur observations the following are used. Small refractors with objective lenses of diameter 50 to 100 mm and, mainly, the Newtonian type reflectors with mirrors of diameter 100 to 300 mm. However the price of “Goto” computerised telescopes has fallen so much that they offer an affordable and easy-to-use solution to the problems of teaching “in the dark”! The standard telescope for amateur use is normally 200 mm aperture.

MAIN TYPES OF TELESCOPES

- The Refracting Telescope

In the refracting telescope, the light passes through the glass objective lens and forms an inverted and real image at its focal point. This intermediate image if magnified by the eyepiece lens. The focal point of the objective and the focal point of the eyepiece are set to correspond. This results in the final image being formed at infinity, so that it is easy for the eye to focus upon. The image will be inverted top to bottom and right to left. This is normal in all astronomical telescopes. In terrestrial telescopes there is an additional lens inserted between the objective and the eyepiece in order to make the final image upright.

The telescope will work perfectly with rays of light that arrive at the objective at a very small angle to the optical axis and when those rays of light are of a single colour. This is not what happens in reality!

The difference between the theoretical image, represented in the simple theory and the reality is significant.

In astronomy the two forms of aberration that are most significant are chromatic aberration, characteristic of the simple lenses in the refracting telescopes and spherical aberration that is characteristic of spherical mirror objectives.
• The Reflecting Telescope

It uses a concave mirror for its objective, perfectly polished and silvered (in fact aluminised) on its front concave face. This is different to normal mirrors, whose reflecting layer is placed on the rear face.

• The Newtonian Telescope

This was the first type of reflecting telescope and is the simplest to explain. Its optical outline is shown in the diagram.

![Figure 8. Newtonian telescope](image)

The objective mirror is concave and parabolic in order to avoid spherical aberration which occurs when parallel rays coming from a distant object fail to cross at the prime focus. Rather they form a “caustic curve”, in fact a surface of revolution that makes it very difficult to achieve a clear focus. Such a “caustic curve” can be seen when sunlight is reflected in a cup of milky tea or coffee.

The secondary mirror is placed in the cone of light reflected by the primary mirror, just before the focal point. It is inclined at 45º to the optical axis so that it reflects the rays through 90º to make the focus in a convenient position to observe with the eyepiece. This type of telescope and particularly with the Dobsonian mounting (see adverts in astronomy magazines) is very popular with amateur observers.

Many decades ago, observers actually worked in a cylindrical cage inside the telescope so that they could position their camera directly at the prime focus. Today it is normal to place a large CCD camera at the prime focus, traditional photography having been abandoned by professional astronomers. The secondary mirror in professional telescopes can be changed in order to achieve different optical arrangements with the same objective, e.g. Cassegrain, Coudé and Nasmyth.

The obstruction caused by the diagonal or secondary mirror to the incident light is not a great problem if the objective is 15 cm or greater in diameter. In a small telescope it should not obscure more than 1/5 of the area of the objective mirror. The material of the mirrors is glass or glass-ceramic, with a very small coefficient of expansion.

The reasons mirrors are used in large telescopes is that they can be made many times larger than lenses. They are front-silvered and so do not have to be transparent to reflect the light. They can be supported are the rear and so can be kept in perfect shape.
The largest single objective mirrors currently available are 8 metres in diameter. However, the Great Telescope of the Canaries uses a series of mirrors in a matrix to create a diameter of over 10 metres.

- **The Cassegrain Reflector**
  In this type of telescope the objective is also a parabolic mirror but with a central hole that permits the cone of light reflected by the secondary mirror to pass through to instruments mounted below. The secondary mirror in this case is of convex hyperbolic form, so that it can reflect and magnify the image.

- **Catadioptric Telescopes**
  There are three basic types: the Schmidt-Cassegrain telescope, the Schmidt camera and the Maksutov-Cassegrain telescope.

**The Schmidt-Cassegrain Telescope.** The secondary mirror is convex and hyperbolic and is located on the interior face of the glass corrector sheet. The image is reflected through the central hole in the main mirror.

![Figure 9. Schmidt Cassegrain Telescope](image)

**The Schmidt Camera.** It is a photographic device. It is a specialised Schmidt-Cassegrain telescope and was used for the very important wide-field surveys from Mt. Palomar in America and from Siding Spring in Australia.

**The Maksutov-Cassegrain Telescope.** In this telescope the correcting sheet is a thick spherical meniscus. At its centre, and near the focus of the primary mirror, a small convex spherical mirror is ground into its rear surface. This reflects the light through the central hole in the primary mirror, making the focus easily accessible. All the optical surfaces of this telescope are spherical and so it is inexpensive to construct. It has great image quality and requires no tricky alignment. However it is difficult to make in large sizes and so is not usually made greater than 180 mm in diameter.

![Figure 10. Maksutov Cassegrain Telescope](image)
TELESCOPE MOUNTS

Mounts are of two types, alt-azimuth and equatorial. The azimuthal type are easy to make and are inexpensive. They have two movements, one for up and down (altitude) and the other for left to right (azimuth). They are not easy to adjust except when used under computer control. However they provide an inexpensive mount in the popular Dobsonian design.

The equatorial mount has two axes. One of them is aligned with the axis of the Earth and so points to the celestial pole. It is called the polar axis and rotation about it allows stars to be followed as the Earth rotates. The other axis allows a particular star to be picked out.

Motor Drive. One can locate objects from their coordinates; and we will attempt an adventure in astrophotography using a motor drive to follow the target.

Stability. An essential for any mount is its stability. If a minor blow causes many oscillations, this can make focusing very difficult. Such a mount will cause so much trouble that it will anger you and you won’t get decent astronomical images either!

Computerised Mounts. Today, thanks to computer technology, it is possible to buy for an acceptable price, a very good alt-azimuth mount that will automatically find and follow a target.

Figure 11. Equatorial mounting: 1 - polar axis; 2 - clamp for setting latitude angle; 3 - graduated latitude angle scale; 4 - motor drive; 5 - control knobs of slow-motion controls; 6 - hour angle setting circle; 7 - saddle; 8 - clamping knob for tensioning declination axis; 9 - declination axis housing; 10 - declination setting circle; 11 - counterweights.
SOLAR SYSTEM (SUN, MOON AND PLANETS)

Mapping out a good planets observation requires careful planning. This paper offers you finder charts and the best times for the observation of planets. The Milky Way rises in a huge arc spanning the eastern evening sky all the way from northeast to the south. Crossways to this broad band some planets are to be seen along the ecliptic which is the apparent annual path of the sun among the stars.

At the time of the EAAE School Mars can be visible during the whole night from 22:50 h to Sun rise, Jupiter during the early night sky from 18:00 h to 23:20 h, Uranus is best seen from 18:55 h to 1:36 h, whereas Saturn rises in the late night sky at 2:48 h and can be observed until the morning dawn in the constellation Virgo. Venus is best seen from 7:25 to 17:12 at daytime by the use of a telescope. Sundials are early at the End of November (Equation of Time EoT = +11.49 min).

Figure 12. Positions of the planets and the Sun

Figure 13. Planets and the sky after sunset
SPECIAL DATA
Madrid, Spain (Latitude: 40° 24’ N; Longitude: 3° 41’ 0” W),
Date: 30.11.2009 Time: MEST

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Figure 14. The planets’ position in November 30th

Figure 15. The planets’ position in November 30th
• Observation of Jupiter’s moons

Jupiter is by far the most massive planet in the Solar System. Easy to observe are its bands, the Great RED Spot and the orbits of its largest satellites.

It is 318 times as massive as the Earth. The atmosphere is 85% hydrogen and 5% helium. The motions in the atmosphere are affected by the planet’s rapid rotation. The period is 9.92 hr at the equator. The rotation period is greater at the poles. The rapid rotation manifested in the appearance of bands and spots, such as the Great Red Spot, which is 14 000 km by 30 000 km, and had persisted for centuries. The most successful model has been to say that the spot is analogous to a hurricane on Earth. East-west winds flow at about 100 m/s near the equator and at 25 m/s at higher altitudes. The winds flow in alternating east-west and west-east bands. These alternating wind patterns correspond to alternating colour bands. On Jupiter, there are five or six pairs of alternating bands in each hemisphere.

The four largest moons of Jupiter are discovered by Galilei in 1610: Io, Europa, Ganymed, Callisto. Observation of the disappearance, the occultation or the transit of Jupiter’s moons is a fascinating task also at the end of November.

Friday 27.11.2009

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Saturday 28.11.2009

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References