Handbook for Teachers and Students

Erasmus+ Project Coordinator by: Voices of the World.eu

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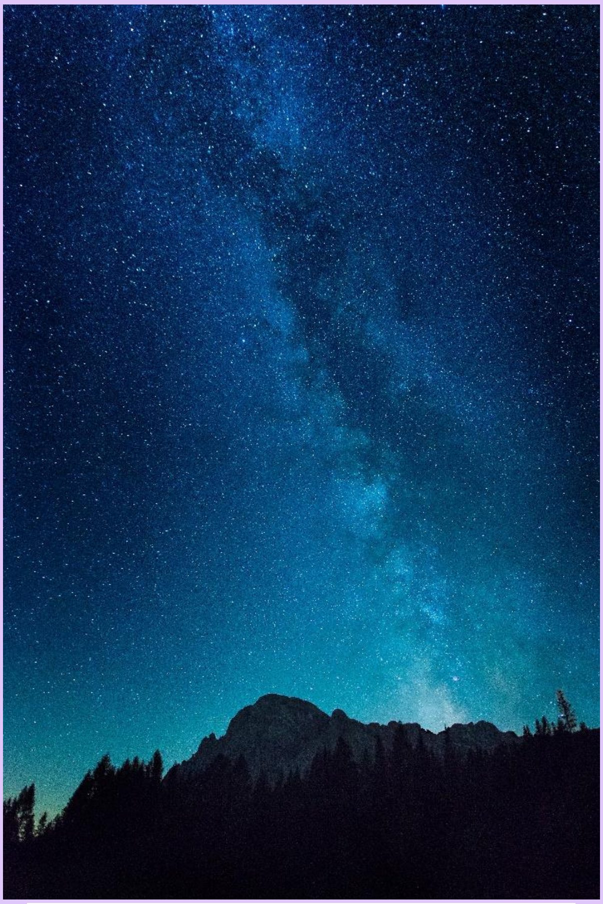
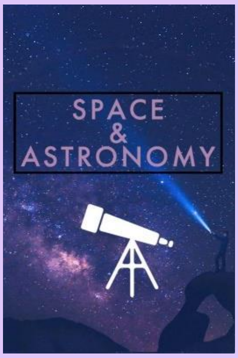


Photo taken during the training activity at Mount Teide, Tenerife with a telescope and professional camera attached. Taken by: Dr. Marco Pezzutto.

Project Trainer & Photographer: Dr. Marco Pezzutto

Project Coordinator: Elnaz Shadras



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Voices Of the World

Space and Astronomy Training

1 Training Material for teachers

Note: you can click on any of the *blue underlined* text to follow the *link.*

1.1 Theoretical approach

1.1.1 Physics and the scientific method

The study of space and astronomy provides an excellent first approach to *physical sciences* and the *scientific method*, which comprises performing *observations* of physical phenomena, formulation of *hypotheses* about them in a *mathematical language*, and testing such hypotheses through further observations and *experiments*. Experiments and theory, technology and mathematics must go hand in hand for us to extend our understanding of the world we live in, and when successful, scientific discoveries should not only extend the range of our *knowledge*, but also empower us by enabling new *technologies* and bringing *wellbeing* to the whole of humanity.

Figure 1: The Andromeda Galaxy.

[Physics](#) is the branch of science concerned with discovering and understanding the *fundamental constituents of the physical world* we live in, and its *inherent governing laws*. While the method of study and research is quite uniform, its domains of application vary widely, covering as much as possible the variety of phenomena that constitute our physical world. Different branches of physics include:

- *Mechanics*: motion and dynamics.
- *Thermodynamics*: heat, work, and energy.
- *Electromagnetism*: electrostatics, magnetism, currents, electromagnetic waves.
- *Atomic and molecular physics*: the structure of the atom and how atoms combine into molecules.
- *Nuclear physics*: the structure of the atomic nucleus, nuclear energy and nuclear reactions
- *Particle physics*: studying the basic building blocks of our physical reality, and their interactions.
- *Fluid dynamics*: the flow and dynamics of fluids.
- *Earth physics*: the atmosphere, weather, and earthquakes.
- *Solid state physics*: understanding the basic properties of different materials from their fundamental components (atoms and molecules).
- *Astrophysics and cosmology*: the physics of astronomical objects, and the dynamics and evolution of the Universe as a whole.

1.1.2 Observing and studying Space

In this project we developed a training that integrates *theoretical lectures* with *practical hands-on sessions* about space, astrophysics, astronomy, and astrophotography. The

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sky has always been a source of wonder, mystery and discoveries for humanity, and has always been the object of studies from the earliest onsets of civilization. Our understanding of space and the universe started with *bare-eye observations* carried out for centuries since the ancient civilizations, improved substantially with the invention of *telescopes* and the development of the *scientific method* in the 17th century, until achieving the depth of contemporary astronomy and astrophysics through modern telescopes and *space missions*, space telescopes, satellites and probes sent across the Solar system.

1.1.3 Astronomy and Astrophysics

Figure 2: Photograph of the Moon taken with a telescope.

Astronomy is the branch of science devoted to the observation, study and understanding of space and everything contained in it: the Solar System, our own Earth's motion in space, other stars near and far from us, galaxies such as the Milky Way, and so many more amazing objects such as black holes, supernovae, nebulas etc. Astronomy relies mostly on observations of space, carried out with a huge variety of telescopes and instruments: from conventional Earth telescopes to radio telescopes, to space telescopes such as Hubble, to even more exotic instruments placed in satellites for measuring the spectrum of radiations, light and particles that come to us, travelling immense distances across space.

Current day astronomy is a very advanced field from both the scientific and the technological aspects; besides, it also enjoys a huge following of amateur enthusiasts across the whole world. In fact, many beautiful objects in space are accessible with small and medium sized telescopes. For example, if you are willing you can enjoy direct views of the planets in the Solar System with just a modest investment of time and resources. Great resources to get started can be found in abundance, for example in the YouTube channels by Forrest Tanaka and Dylan O'Donnell.

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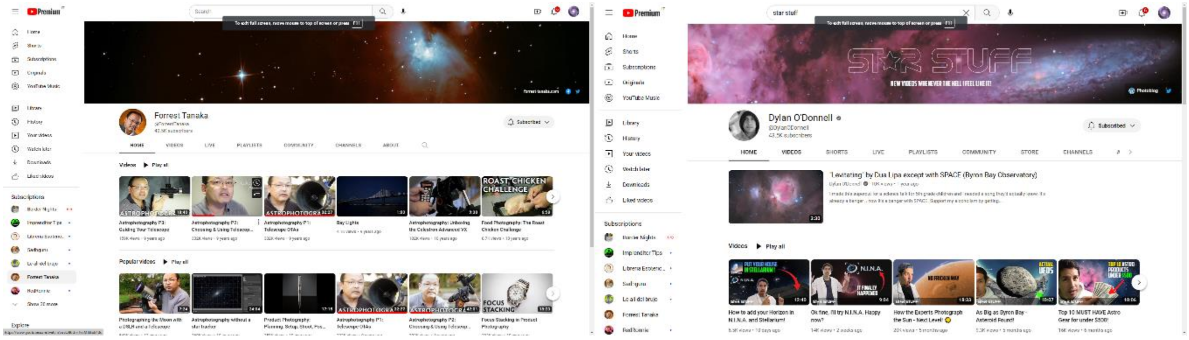

Figure 3: YouTube channels on astronomy by [Forrest Tanaka]() and [Dylan O'Donnell]().

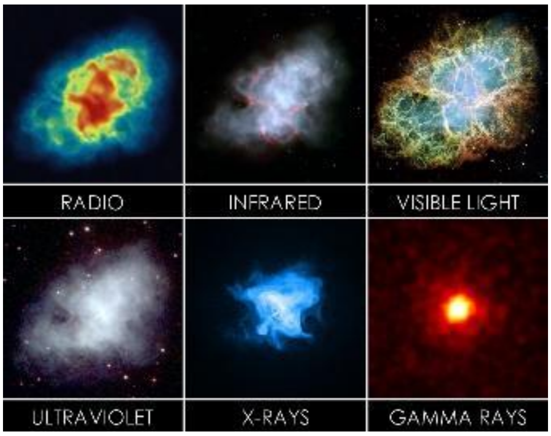

Figure 4: Images of a nebula taken in different ranges of the electromagnetic spectrum.

[*Astrophysics*]() is [closely related to astronomy]() and consists in the application of the methods of physics to space. It comprises areas such as the study of the *light and particles* arriving on Earth with the methods developed in *particle physics* laboratories, or the application of the laws of *gravitation and general relativity* to the motion of celestial objects and to the evolution of the Universe as a whole (*cosmology*), or even the application of *quantum physics* to the study of *black holes*.

1.1.4 Telescope fundamentals

The king tool for any astronomer is the [telescope](). These simple yet amazing devices were invented in the Netherlands in the early 17th Century and were perfected over time by great astronomers and scientists such as Galileo Galilei, Johannes Kepler, Isaac Newton, Laurent Cassegrain. They evolved on one side into very large and complex devices used by professional astronomers, and on the other side into relatively simple devices accessible to the general public of sky and space enthusiasts.

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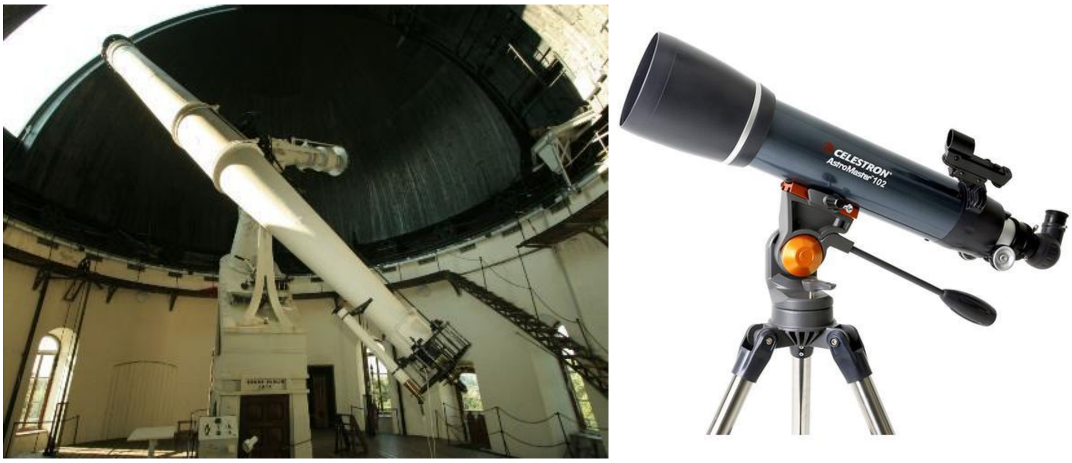

Figure 5: Refractor telescopes. Left: the 68 cm refractor at the Vienna University Observatory. Right: an amateur refractor with alt-azimuth mount.

Whether it’s a large telescope in a remote observatory, or an amateur telescope that one can use in the backyard, the basic working principles of every telescope are the same:

- a large main *light focusing device*, either a *lens* or a *mirror*.
- an *eyepiece*, to enable direct observation, or alternatively a *camera* to collect the image.
- a *focusing* mechanism, to adjust the telescope to the distance of the observed object.
- Optionally, additional optical elements to *enhance the power* of the telescope.
- A *mount* and a *tripod* or platform, to support the telescope and keep it aligned in the desired direction, and possibly to *track* the observed object with computerised motors.
- A *pointing* device (sight, accessory telescope, computerised system etc.), to aim the telescope in the desired direction.

Small amateur telescopes are built to work in the range of *visible light*, while large observatory telescopes can go beyond and collect images in the *infrared* and *ultraviolet* ranges of the electromagnetic spectrum. In addition, astronomers often use dedicated devices to collect “images” in frequency ranges far from the visible, such as *x-rays*, *gamma rays* and *radio*.

The basic properties of any telescope can be summarised in few key specifications:

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- **Focal length:** *a telescope's enlarging power* – The focal length of a telescope is the distance behind the telescope at which the rays of light, coming from an infinitely far object, are concentrated. It is directly proportional to the telescope's enlarging power.
- **Aperture**: *a telescope's light gathering power* – This is the physical aperture of the telescope: the larger the aperture, the larger is the amount of light that can be collected. With more light, a telescope can provide a brighter image, reveal dimmer objects in the sky and allow for astrophotography with shorter exposure times.
- **Relative aperture:** *a telescope's light flux measure* – It is the ratio between focal length and aperture; it measures the light flux that a telescope can deliver at the eyepiece or camera. It is very useful to compare different telescopes.

1.1.5 Types of telescopes

There exist three [types of telescopes] which are broadly accessible to the public of enthusiasts and amateurs, excluding advanced dedicated equipment found in observatories. Each type has advantages and disadvantages, and no one is remarkably better or worse than another; rather, each can be more or less suited to a particular observational purpose.

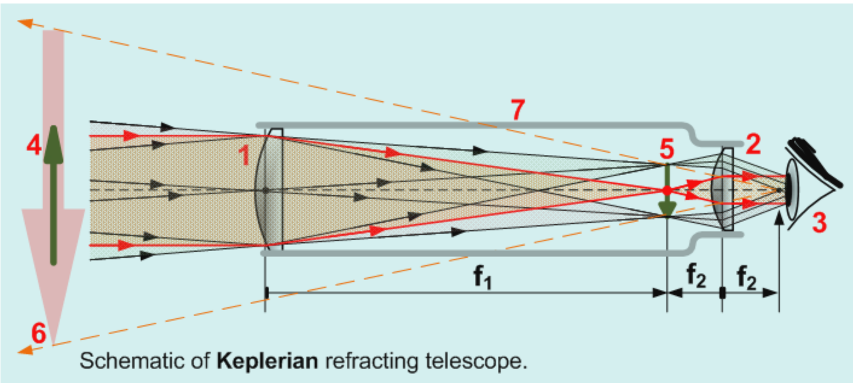

Figure 6: Keplerian refractor telescope. Left: optical scheme; right: portrait of Johannes Kepler.

Refractor (Keplerian) – This is the very first type of telescope invented. It comprises two optical elements: the front *converging optical element*, for main light gathering and concentration, and the *eyepiece*, for visual observation. While the very first devices

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employed the Galilean optical scheme, all refractors available today use the later Keplerian scheme instead. These telescopes are simple to build, quite affordable, usually light to carry, and offer great image quality for astrophotography, with ease of operation. They are however usually quite long, not very bright (medium to small relative aperture), and the simpler models can be prone to aberrations and colour fringes, although these are well corrected in the best models.

Reflector (Newtonian) – The Newtonian reflector employs a *concave primary parabolic mirror* instead of a lens, together with an *eyepiece* for direct visual observation. Since the mirror is located at the bottom of the telescope, the eyepiece must be placed near the front opening; thus, a flat mirror positioned at a 45° angle needs to be placed inside the telescope near the main opening, to direct the light gathered by the main mirror towards the eyepiece. Reflectors are also extremely popular among astronomers, because of many reasons: high quality for the price, easiness of manufacturing and building, high relative luminosity, and being free from chromatic aberrations. They are however relatively larger than comparable refractors, they don't reach great powers usually (only short to medium focal lengths), and can be prone to coma if the mirror is spherical instead of parabolic, which is often the case because of cheaper and easier manufacturing.

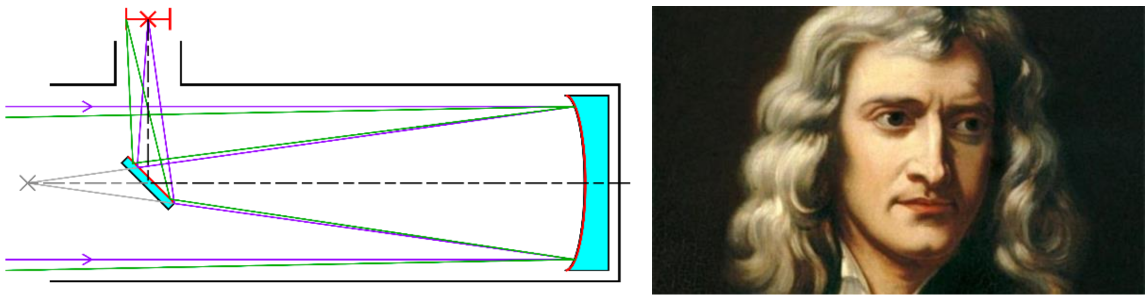

Figure 7: Newtonian reflector telescope. Left: Optical scheme; right: portrait of Isaac Newton.

Besides, they are not so easy to use for astrophotography, requiring dedicated adaptations. These are minor limitations that can be circumvented quite easily, and Newtonians rightfully enjoy great success among astronomers.

Cassegrain and Catadioptric (Schmidt-Cassegrain, Maksutov-Cassegrain) – The Cassegrain telescope design and its variations constitute a modification of a Newtonian, to achieve *more enlarging power* (longer focal length). They do this by

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adding a *second convex hyperbolic mirror* in front of the primary concave parabolic mirror. A hole in the centre of the primary mirror allows the light to be directed to the eyepiece, behind the primary mirror. While the design is simple, the exact manufacturing of the curved mirrors can be difficult. Because of this, very often the primary and secondary mirrors are substituted by *spherical* mirrors, at the cost of introducing optical aberrations. These defects are then corrected with the *addition of a lens* in the optical path, leading to a so-called *catadioptric* design. The Schmidt-Cassegrain and the Maksutov-Cassegrain are the two most common optical designs implementing this solution. Catadioptric telescopes are very successful, because they are usually very compact and therefore portable, they can be very powerful, and they are as easy to use as a refractor for astrophotography. They usually have small to medium apertures and are comparatively more complex and expensive than refractors and reflectors. Still, they represent an excellent compromise, in fact most high-end amateur telescopes are of this type.

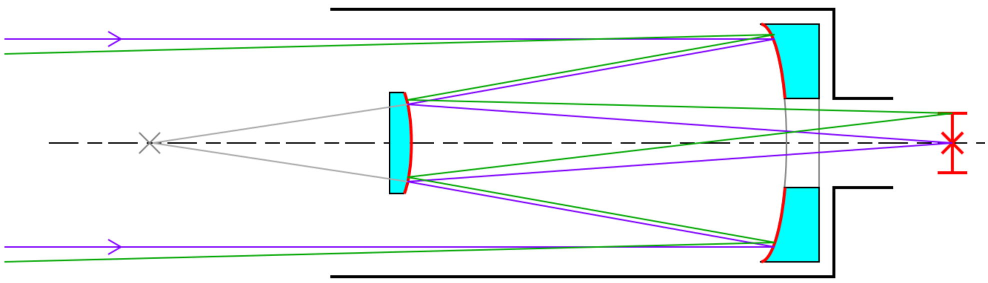

Figure 8: Optical scheme of a Cassegrain telescope.

1.1.6 Basics of photography

Astrophotography is a fundamental part of astronomy, being the basic technique for obtaining *direct proofs* and traces of astronomical observations. It is also an immensely rich field of *creative photography*, providing a broad spectrum of subjects and opportunities for creating beautiful images: from broad views of the Milky Way on a clear and dark night, to pictures of planets in the solar systems and the Sun itself, to views of nebulas and other galaxies.

Photography has become increasingly popular and easier thanks to the technological advantages of the last few decades: from electronic exposure automation, to autofocus, to the direct feedback and cost cutting benefits of digital cameras, up to extreme portability, good quality and ease of sharing of today's smartphone cameras.

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While many types and genres of photography have become easier and more accessible, astrophotography is still one of the most technically demanding areas of photography; therefore, to get started in astrophotography one needs to grasp the basics of photography itself.

Photography can be intended both as a *tool, a technique* for creating 2-dimensional images through a mechanical, a chemical or electronic process, and as a *visual language*. It is a practice, a means of creating images, independently of their use or purpose. Photography is often used for a variety of destinations and intentions: documentation, evidence, news, artistic expression, persuasion (advertisement) etc…

The technical aspect and the communication, visual and aesthetic aspect are complementary and both important for the creation of a successful photograph. A discussion on what makes an effective photograph from the visual and communication point of view is beyond the scope of this magazine, so from now on we will focus on the technical aspects of photography.

1.1.7 Basics of camera components and operations

In the following, we will review some key concepts of photography. From our 3-dimensional dynamic world, light is collected and focused by a camera's *lens*, and projected onto some surface holding a *light-sensitive medium*: a piece of *film* or a *digital sensor*. A camera usually allows us to choose *how much light* comes to the sensitive medium, and for *how long*. The result is a *static image,* which can be recorded, stored, printed, copied, transmitted.

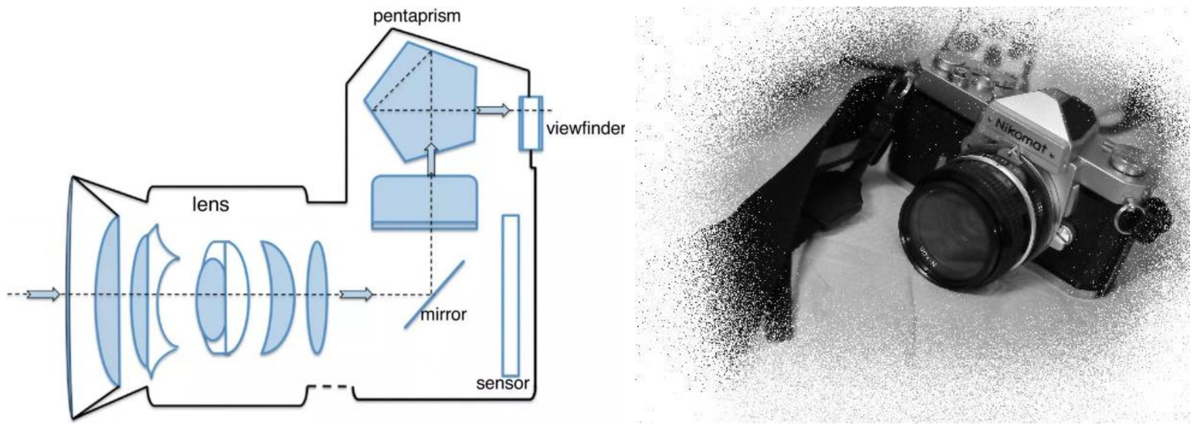

Figure 9: Single Lens Reflex camera. Left: schematic design; right: example of a film single lens reflex from the late Seventies.

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The *essential components* of any camera are:

- **Light-tight box:** it creates the *dark environment* where the sensor/film is exposed to light.
- **Lens:** it *creates the image* – It focuses the light to the focal plane on the sensor/film.
- **Recording medium:** light-sensitive material, either *film* or a *digital sensor* + memory card.
- **Viewfinder:** it allows the photographer to *pre-visualize* and *compose* the image.

Even though there exists a great variety of camera types, some *essential controls* are always present:

- **Lens Focus:** to be set according to the *subject/camera distance*, to deliver the sharpest image.
- **Lens aperture:** it is the *wideness of the hole* through which light passes. It is controlled with a device called **diaphragm,** just like the *iris of our eye* changes the wideness of our *pupil.*
- **Shutter speed:** it is the *duration* during which the film/sensor is *exposed to light.* This is achieved through a mechanical or electronic device called *shutter.*
- **ISO sensitivity**: it is a measure of the *responsiveness to light* of the film/sensor. For film photography, it is a fixed property of the film. In digital photography, the light reaching the sensor generates an analogue electronic signal, which can *be electronically amplified*. The ISO sensitivity controls the magnitude of this amplification.

Figure 10: Basic camera controls: focus, aperture, and shutter time.

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Lens aperture, shutter speed and ISO sensitivity together constitute the three **exposure controls,** allowing us to adjust the camera according to *the huge variety of light levels* of the world outside. In fact, we need to make sure that just the *optimum amount of light* reaches the film/sensor for the best image capture, so that the image is neither too dark nor too bright.

A wealth of material about the basics of photography is available online, and we recommend:

- Free eBooks on Photzy.com - resources for photography training, from getting started to advanced techniques in many.
- free guides on photography basics by Dan Zafra.
- free tutorials by Phil Steele.
- course by Phil Steele on camera fundamentals.

Figure 11: Online resources on the fundamentals of photography: photzy.com, capturetheatlas.com by Dan Zafra, and steeletraining.com by Phil Steele.

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1.2 Practical approach

In this training we gave a prominent role to *practical activities*, believing that these sessions can facilitate *learning by doing and by experience*, while encouraging *collaboration* among students, development of *team-play* skills, *social and emotional intelligence*. Therefore, we lead the students through various practical sessions, as detailed in the following.

1.2.1 Assembling a telescope.

For conducting a successful astronomical observation session, one needs to gain sufficient mastery and knowledge of the basic operations and parts of a telescope. With this in sight, the students *assembled a telescope starting from its basic components*, so that they could observe, test, and understand each element, its function and how to operate it. It is essential that this preliminary activity is carried out during the day, with plenty of light and no rush, so that sufficient familiarity with the device is gained. This way, one can later find himself or herself at home also during the night observation sessions.

1.2.2 Usage of telescope: polar alignment and observation

Figure 12: Astronomy and astrophotography session near Nevşehir, Turkey.

After the preparation, we were ready for a real astronomy session at night. In this experience, the students brought the telescope to a chosen *outdoor observation site*, far enough from the city centre to reduce the effects of *light pollution*. First, they had to *reassemble* the telescope in the site, then *test* that all the fundamental operations work as intended (pointing, movements, collimation of sight).

The next step is the crucial *polar alignment*, which is possible if the telescope is supported by an *equatorial mount*. To learn more we recommend the video by Forrest Tanaka, but in short, polar alignment consists in *aligning one of the rotation axes for pointing the telescope, with the Earth's own rotation axes*. In practice, this can be done precisely by *pointing the telescope to Polaris* with the equatorial mount movements, then setting this position as the *base position* for further pointing of other sky objects. Thanks to this, the movement of celestial objects across the sky due to the *Earth's own rotation* is easily compensated by operating just one movement on the telescope, the so-called *Right Ascension.* The other movement required for pointing an object in the sky is called *Declination*. If the mount is motorised, *automatic tracking* of celestial bodies becomes possible.

Figure 13: Astronomy and astrophotography session near Nevşehir, Turkey.

In case this precise alignment is not possible because Polaris is not visible, a more approximate alignment can be done by setting the *azimuth* control of the equatorial mount towards *North* with the aid of a compass, and the *altitude* control of the mount at a degree corresponding to the *latitude* of the site of observation. The polar alignment done in this way is never accurate enough for astrophotography, non the less it allows for easy tracking of celestial objects for visual astronomy.

Once polar alignment is achieved, we are ready for the observation of any object in the sky. In case the telescope has a simple manually controlled mount (not a computerised one), one can point the telescope to any visible object in the sky. This is quite easy with the aid of a *sight* or *finderscope,* usually included with every telescope. A variety of objects is observable with this procedure, including the nearest planets of the Solar system, the Moon and many near stars.

1.2.3 Usage of camera at night

Astronomical photography is usually carried out *with telescopes* or *long telephoto lenses*. There are however many possibilities that one can explore even with a *normal camera and lens*, such as *star constellations*, *night landscapes* including the night sky, and especially the wonderful *Milky Way*.

Milky Way photography is quite different from any other type of astronomical photography. The galaxy we live in, when visible, *spans across the whole sky*, therefore it is best photographed with *wide or ultrawide lenses*.

While modern digital cameras can easily take care of the technical burden in a lot of photographic situations, unfortunately for astrophotography this is not the case. It is in fact a rather technical application of photography, where automatic systems can't do much. Therefore, one needs a good grasp of a few key technical aspects and settings.

The first step towards astrophotography with a normal camera (especially of the Milky Way), is gaining familiarity with the basics of night photography:

- Operating the camera on a *tripod*
- Firing the camera with a *remote trigger* (cable or radio), or with self-timer
- *Measuring and setting exposure manually*
- *Setting the focus manually*
- Setting the camera's *image digital controls* (ISO, sharpness, contrast etc.) for the best quality

While all these operations and controls are usually straightforward, performing them at night, in the dark and with limited time available due to changing environment conditions, can be challenging.

1.2.4 Photography of the Milky Way with a normal camera

Astrophotography of the Milky Way requires particular care. Fortunately, one can find many good resources online devoted to this, such as the tutorial by Jenn Mishra for getting started with astrophotography, or many articles by Dan Zafra on Milky Way photography.

Figure 14: The Milky Way; picture taken during the training.

The *preparation* is of paramount importance, starting with the very *choice of site and timing*. We will go into this in the next section.

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When on the field, the first technical challenge is setting the *focus* correctly on the far stars in the sky. This needs to be done *manually*, for example pointing at one of the brightest stars, a planet, or a light on earth very far away. Once done properly, focussing can be left alone for the rest of the session.

The second crucial technical aspect *is setting the exposure controls* (ISO, aperture, shutter speed) for the best possible image with the equipment available. The Milky Way is very dim, so it requires a very *long exposure time* with a *wide aperture* and somewhat *high ISO*. However, if using a conventional camera tripod*, one cannot use too long a time*, otherwise the Earth motion will cause the stars to form *trails*, that is, they will appear as lines instead of just points. Also, it is always best to *keep ISO as low as possible* to reduce electronic *noise* and preserve image quality. Furthermore, most lenses can show *coma* (a type of optical aberration) when used wide open, therefore one should *close the diaphragm a bit* for the best results. A good strategy can be the following:

1. Set the *lens aperture wide open* (or at most closed by 1 stop to reduce coma).
2. Set the *shutter speed as long as possible*, but not too long as to form *star trails*. This will require some trial and error, but a thumb rule is that if one is using a lens of focal length *f,* the best exposure time is around 400/*f.* For example, with a 20 mm lens, the maximum time is around 20 seconds.
3. Set the *ISO as high as needed* to have a bright enough image. Typical values can be around 3200 to 12800. Bear in mind that since this is a night photo, one or two stops of underexposure compared to usual is acceptable.

1.2.5 Astrophotography with a telescope: smartphone, conventional camera, dedicated telescope camera

Astrophotography with a telescope can be challenging, but the results always reward all the effort. There are two main difficulties:

- One needs a *motorised equatorial mount* and to perform *a very good polar alignment.*
- *Exposure times can be very long*, with all the implied challenges.

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Figure 15: Astrophotography with a telescope. Left: Jupiter and three of its satellites. Right: The Moon.

There are various ways for taking a picture of the image created by a telescope:

1. The simplest and easiest way is to attach a *smartphone* on the telescope *behind the eyepiece*, to capture the image coming right through it. The quality level can vary a lot, but it is a good first step. One needs a way to trigger the phone camera remotely.
2. A much better solution, even though still a compromise, is attaching a *digital camera* to the telescope, either a digital reflex or a mirrorless camera. This is easily done with a dedicated *adapter*. It is usually straightforward with refractors and Cassegrain-like telescopes, while it can be trickier, but still feasible with Newtonians, because of some inherent technical features of Newtonians, that make focusing more complicated and need special care. This approach is a very good compromise between image quality and practicality, especially if one already has a camera available. Once connecting the camera and focusing are sorted out and provided the telescope is capable of good tracking, photography is straightforward and very similar to any other night photography situation.
3. Using a *dedicated telescope camera*. This is the best option, allowing for exploiting the telescope to its full extent and obtaining the best possible images. There exists a great variety of astronomical cameras, suited for different purposes, but even an entry level one is a step up compared to using a normal camera. A practical limitation is that all these dedicated cameras usually work connected to a computer; this may not be an issue if operating near a building, but it can be challenging if one goes to some remote location.

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1.3 Astrophotography: planning and preparation

Conducting a successful astronomy or astrophotography session requires some *simple but fundamental planning* in advance. In fact, we are challenging ourselves in observing and capturing *natural objects and phenomena*, be it the Moon and its phases, a planet, or the Milky Way, so we need to be aware of their motion and evolution in the sky, and of the natural conditions of the location from where we wish to carry out the observation.

The first step is of course deciding *what* we wish to observe, that is, which celestial object we are interested in. Then, we need to do some research about *when* the celestial object is visible from *where* we plan to perform the observation. Luckily, there is plenty of information available and accessible online, in the form of calendar tables, or even more easily in dedicated apps, such as [Star Chart](), [Photopills]() or [The Photographer's Ephemeris](), or [Moon Phases](), specifically dedicated to the Moon.

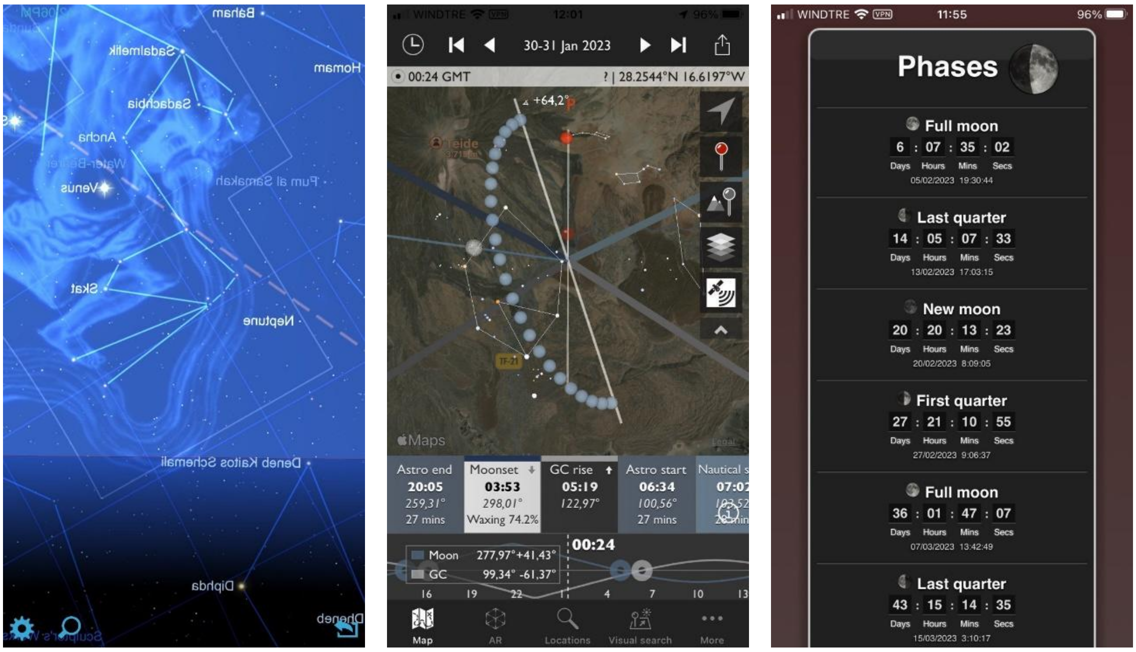

Figure 16: Applications for astrophotography planning: Star Chart, The Photographer's Ephemeris and Moon Phases.

Special care needs to be put on the choice of the *observation point*, for two reasons: first, the same object may be visible in *different periods of the year*, or at *different times of the day*, from different locations; second, we need to ensure that at the observation

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site *light pollution* is sufficiently low. Many online resources are dedicated specifically to this, for example Dark Site Finder.

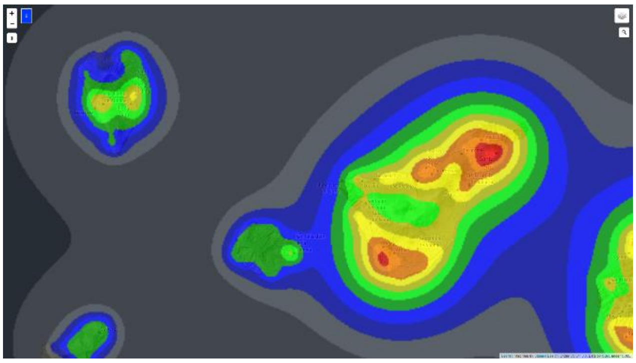

Figure 17: Example of light pollution map from darksitefinder.com.

Next, depending on our choice of celestial object to observe, we need to select the best equipment in our reach that will allow us to observe and capture it. Or, much more practically, we will do our best with what we have. In any case, we need to gain as much familiarity and mastery with our equipment as possible, before and during the observation session, for achieving a satisfying observation. Bear in mind, however, that a photographic capture may be more challenging and time consuming than a simple visual observation. In any case, we need to choose and *prepare* the equipment we will use carefully, plan the *transport* to the chosen observation location, in case a trip is involved, and factor in the time required to reach the location and *set up* the equipment.

Finally, the last thing to check carefully is… the *weather*! Even though this may sound obvious, this is as important as the previous points in the preparation of an observation.

1.4 Photo Editing and Processing

It is easy to think that once an observation and astrophotography session is concluded successfully, we're done, and sometimes this is indeed the case. More often, however, digital capture is only one step in a larger process that continues and culminates with the *editing*, *processing* and *final image export* in the computer. For this reason, we included in our workshop various training sessions covering the basics of digital image editing and processing. A huge wealth of training material exists online, both on

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general photo processing and on techniques for astrophotography. Among others, Photzy.com offers both free tutorials and more advanced training material.

Figure 18: Adobe Photoshop Lightroom Classic.

Once our photos land on the computer, the first step is always… *looking at them*! Thanks to digital capture, we can take as many pictures as we wish, but we rarely if ever need all of them, so the very first step is *choosing our best images*, so that later in post processing we can focus our efforts on them only. For a few pictures this can be done simply with our computers' finder/explorer program, but for larger numbers and better efficiency, many applications have been created specifically for this purpose. The most popular is by far *Adobe Lightroom*, for which a huge wealth of training material exists online, for example the Lightroom course by Phil Steele.

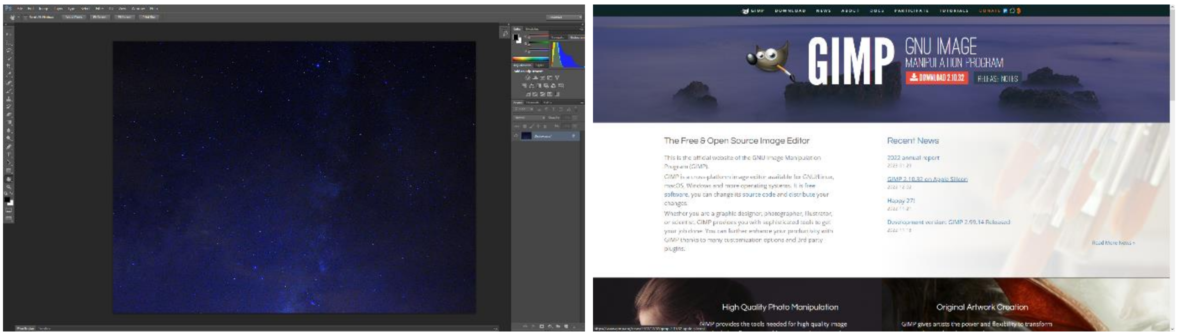

Figure 19: Photo processing software. Left: Adobe Photoshop. Right: GIMP.

The next step is the core processing of the selected pictures in some specialised software, the most known and industry standard being of course Adobe Photoshop. Even though it is paid software, *discounts exist for schools and educational institutions*. Phil Steele offers a course on Photoshop too, and online one can find countless tutorials, articles and videos. One can also experiment with many free alternatives to Photoshop, among which the best and most complete is GIMP.

Going into photo processing aspects which are more specific to astrophotography, we just mention here two techniques:

- *Noise reduction*: this step is all-important in astrophotography, since most likely the images are taken at medium to high ISO values. Lightroom, Photoshop and most photo processing applications have built-in tools for this, which usually perform a good job. However, for the best quality there are few applications dedicated to this task, such as Topaz DeNoise AI.
- *Stacking*: this operation consists in taking many pictures of the same subject, in sequence, and combining them together to get a final image with more detail and less noise than any of the individual initial images. This can be done in Photoshop with a bit of work, and dedicated applications exist specifically for this purpose, for example Sequator.

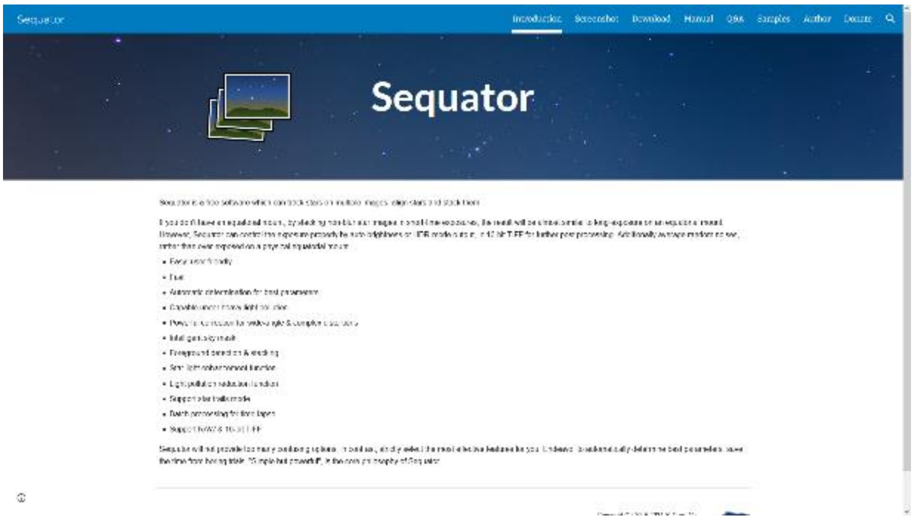

Figure 20: Sequator, an application for automatic stacking of astronomical images.

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