

Young Astronomer Briefcase

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Summary

To further observation it is necessary that students have a set of simple tools. It is proposed that they construct some of them and then use them in observing the sky from the school itself.

Students should understand in a basic way how various instruments have been introduced over the centuries, how they have developed, and have become necessary. It is an important part of astronomy, noting the great ability to build them and the skill to use them to do readings of the observations. These requirements are not easy to develop with students and for that reason here we propose very simple instruments.

Goals

- Understand the importance of making careful observations.
- Understand the use of various instruments thanks to the fact that students do the construction by themselves.

The Observations

We can acquire some practice in the measurement of time and positions of celestial bodies with prepared artifacts "ad hoc". Here we give some information to gather a collection of tools for observation in a suitcase. The suitcase and contents are generally made of cardboard using glue, scissors, etc.. The topic may offer the possibility to investigate many other ancient and modern instruments.

The artistic and imaginative ability of students will allow very personal suitcases. This activity can be easily modified and adapted to the students depending on their age, with more or less sophisticated tools.

In particular, this suitcase contains:

- A ruler for measuring angles
- A simplified quadrant
- A horizontal goniometer
- A planisphere

- A map of the Moon
- An equatorial clock
- A spectroscope

We propose a suitcase with very simple tools. The small suitcase can be easily taken to school or during free time, ready for use. It is important this is not too large or fragile (especially if it is to be used by very young students). We emphasize that exactness in the measurements is not the end of this activity.

Contents

We obviously can only simulate this on a schoolyard in the summer. The idea is to get practice with the tools that we will do here now.

First, we need a cardboard box like the ones you receive by mail with a book inside (this will be the suitcase). It is necessary only to place a handle on the narrow side and that the wide side could be opened. Inside the box, we will post the following instruments:

- ❖ A **"ruler to measure angles"** that can be used to give us the angular distance between two stars of that constellation. It is very easy to use if we don't want to introduce the coordinates.
- ❖ A **simplified quadrant** can be used to obtain the height of the stars. When students see an object through the viewfinder the string indicates the angular position related to its horizon.
- ❖ A simple **horizontal goniometer** can be used to determine the azimuth of the stars. Obviously you need to use a compass to orient the instrument in the North-South direction.
- ❖ A **planisphere** with the constellations photocopied very clearly onto a disc of white paper and a cardboard pocket with the "hole" of the latitude to put the disk of the sky inside. Turning the disc we find the date and time of observation to recognize the major constellations at the latitude of the "hole" that we use.
- ❖ A **spectroscope** to separate light into the seven colors that compose it.
- ❖ A **map of the Moon** with the names of seas and some craters that are easily recognizable through binoculars.
- ❖ A **flashlight** (red light) to illuminate the maps before looking at the real sky. Bright white light will make it difficult for the students' eyes to adjust to the darkness. If students bring a flashlight in their suitcase, you need to put a red filter on the front. A group of students with white flashlights can produce a lot of light pollution making the observations more difficult.
- ❖ A **compass** for aligning the different instruments.
- ❖ And of course all the accessories that needs every student: notebook, pen, a watch and, if it is possible, a camera

Following the instructions and drawings we can get our tools in a very simple way and use them outdoors. During the day we'll measure, for example, with the quadrant the position

(height) of a tree, a hill, and so on. At night, we can measure the position of two different stars or the Moon in order to understand the periodic cycle of its phases. We encourage students to take data.

For the first nighttime observations it is better to use simple maps prepared in advance to become familiar with the most important constellations. Of course the astronomical maps are very accurate but the experience of teachers suggests that sometimes, without assistance, they are initially confusing.

A ruler to measure angles

Considering a simple proportion we can build a basic instrument for measuring angles in any situation. Our main aim is to answer the following question: "What is the distance (radius R) that I need in order to obtain a device that 1° is equivalent to 1 cm?".

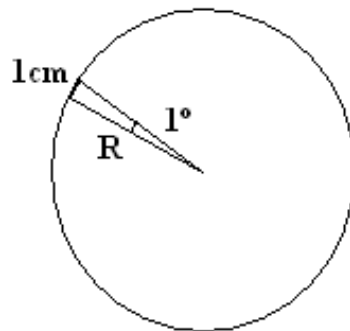


Fig. 1: The radius R in order to obtain an instrument where 1° is equivalent to 1 cm.

In figure 1 we consider the relationship between the circumference of length $2 \pi R$ in centimeters to 360 degrees, with 1 cm to 1° :

$$\frac{2\pi R \text{ cm}}{360^\circ} = \frac{1 \text{ cm}}{1^\circ}$$

So,

$$R = 180 / \pi = 57 \text{ cm}$$

To build the instrument: We take a ruler, where we fix a string of 57 cm of length. It is very important that the string doesn't stretch.

How we use it:

- We watched with the end of the rope almost touching our eye "on the cheek, under the eye"
- We can measure using the rule and the equivalence is $1 \text{ cm} = 1^\circ$ if the string is extended (figure 2)

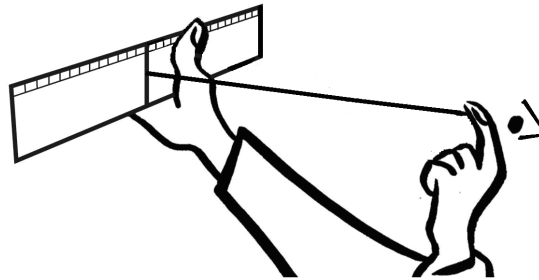


Fig. 2: Using the instrument (a ruler and a piece of string 57 cm long), we can measure angles with the equivalence “1cm = 1°”.

Proposed exercises:

What is the angular distance between two stars of the same constellation? *Use the "ruler to measure angles" to compute the distance (in degrees) between Merak and Dubne of Ursa Major.*

A simplified quadrant: quadrant "gun"

A very simplified version of the quadrant can be very useful for measuring angles. Here we present the "gun" version that is user friendly which encourages their use by students.

To build it: You need a rectangular piece of cardboard (about 12x20cm). We cut out a rectangular area as in figure 3 in order to hold the instrument. We place two round hooks on the side (figure 3).

In a paper quadrant (figure 4) with the stick angles shown (figure 3) so that one of the hooks is on the position 0° (figure 3). Tie a string on the top and at the other end attach a small weight.

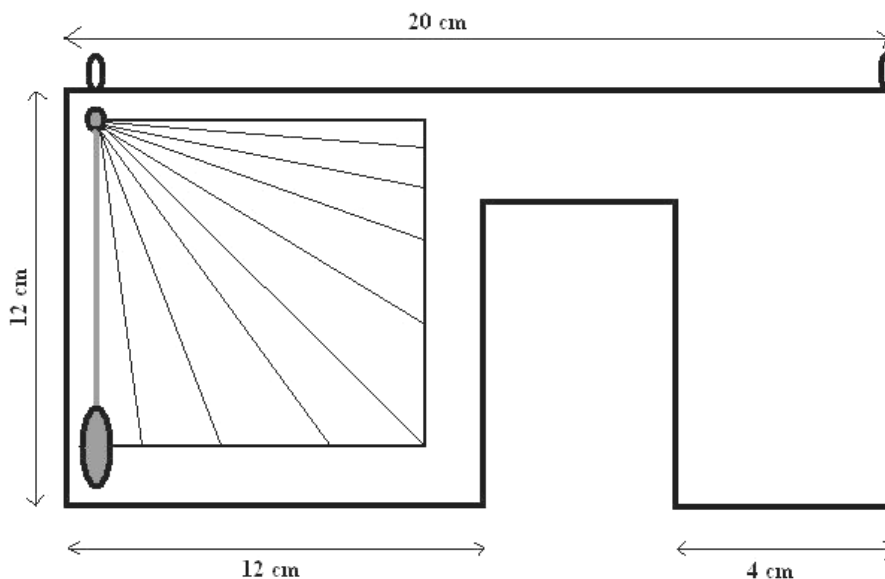


Fig. 3: Quadrant “Gun”.

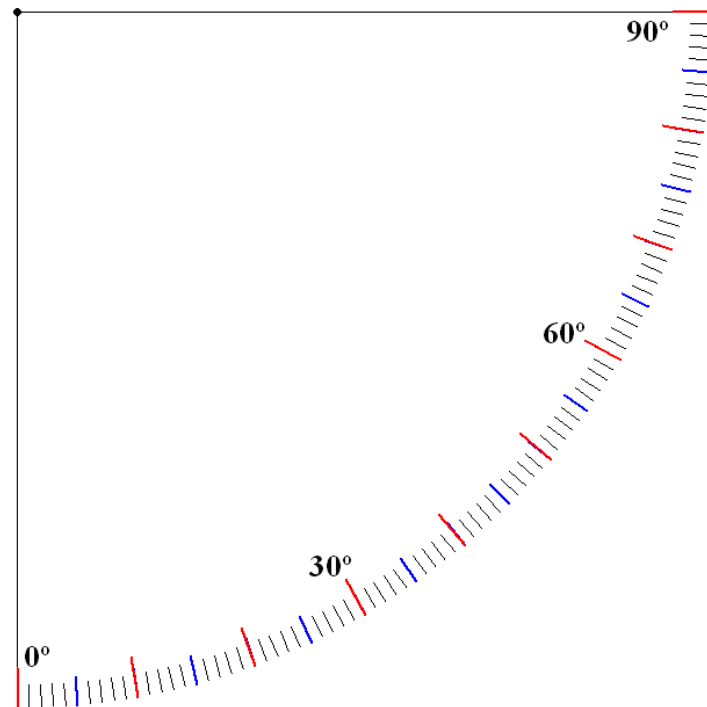


Fig. 4: Graduation of 90 ° to stick on the quadrant.

How to use it?:

- When viewing the object through the two hooks the string indicates the angular position 0 ° refers to the horizon (figure 5b).
- A straw passing through the hooks is an excellent viewer that will allow us to measure the height of the Sun by projecting the image onto a piece of white cardboard. CAUTION: DO NOT EVER LOOK DIRECTLY AT THE SUN!!!

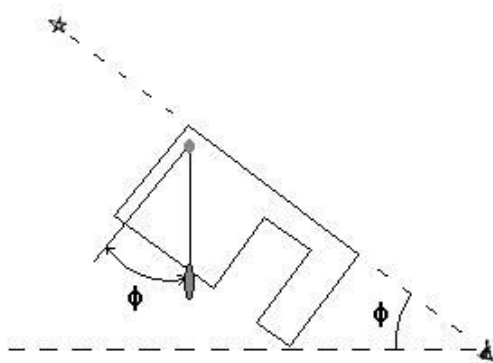


Fig. 5a and 5b: Using a “gun” style quadrant.

Exercises proposed:**What is the latitude of the school?**

We will use the quadrant to measure the height of Polaris. The latitude of a place is equal to the height of the Pole at that place (figure 6).

You can also use the quadrant to compute (in math class) the height of the school or another nearby building.

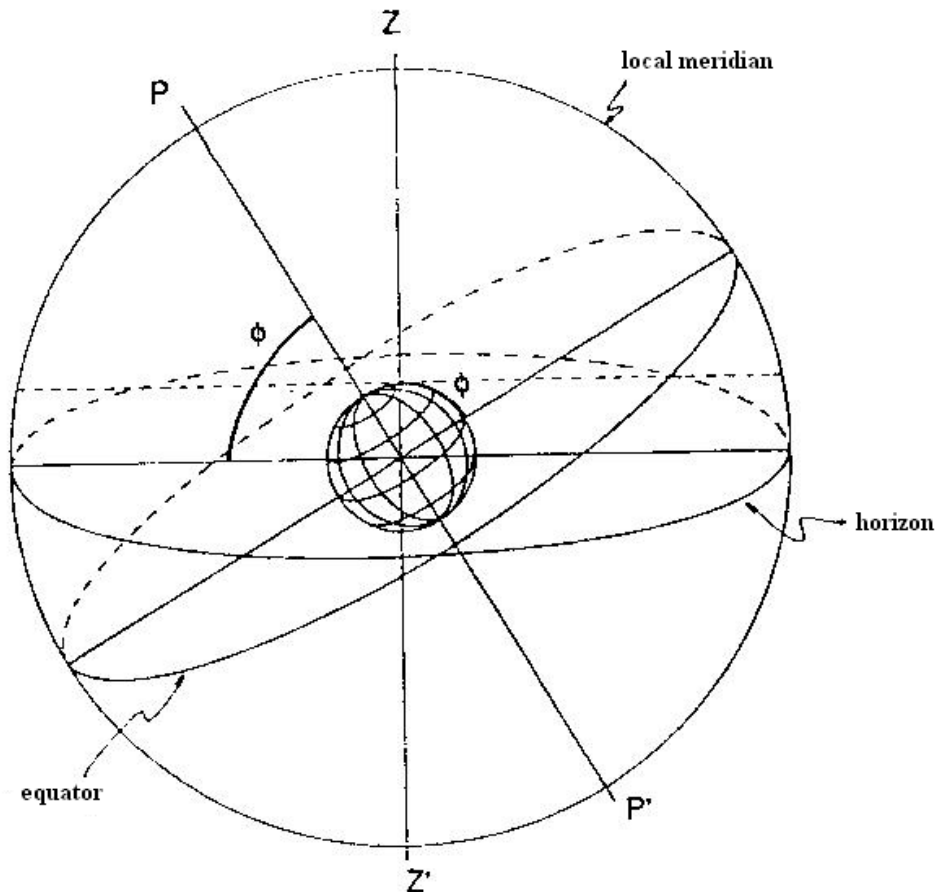


Fig. 6: The latitude of the place ϕ is equal to the height of the Polar.

Horizontal Goniometer

A simplified version of horizontal goniometer can be used to know the second coordinate needed to determine the position of a celestial body.

To build the tool: Cut a cardboard rectangle about 12x20cm (figure 7a). We stick a semicircle of paper (figure 8) with the angles indicated so that the diameter of the semicircle is parallel to the longest side of the rectangle. Using 3 "needles" we can mark two directions in the goniometer (figure 7b).

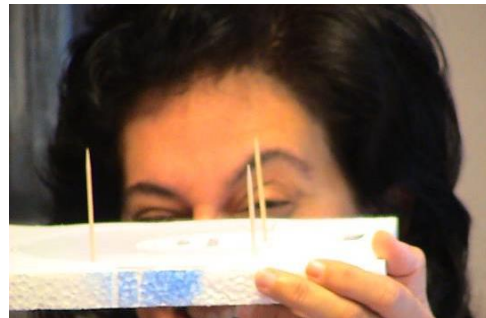
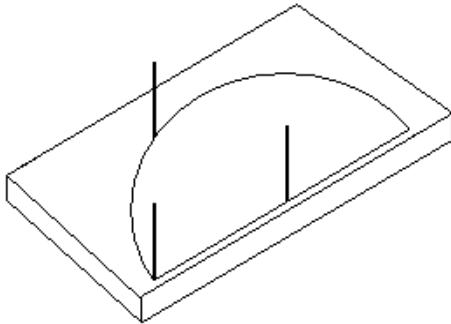


Fig. 7a and 7b: Using the horizontal goniometer.

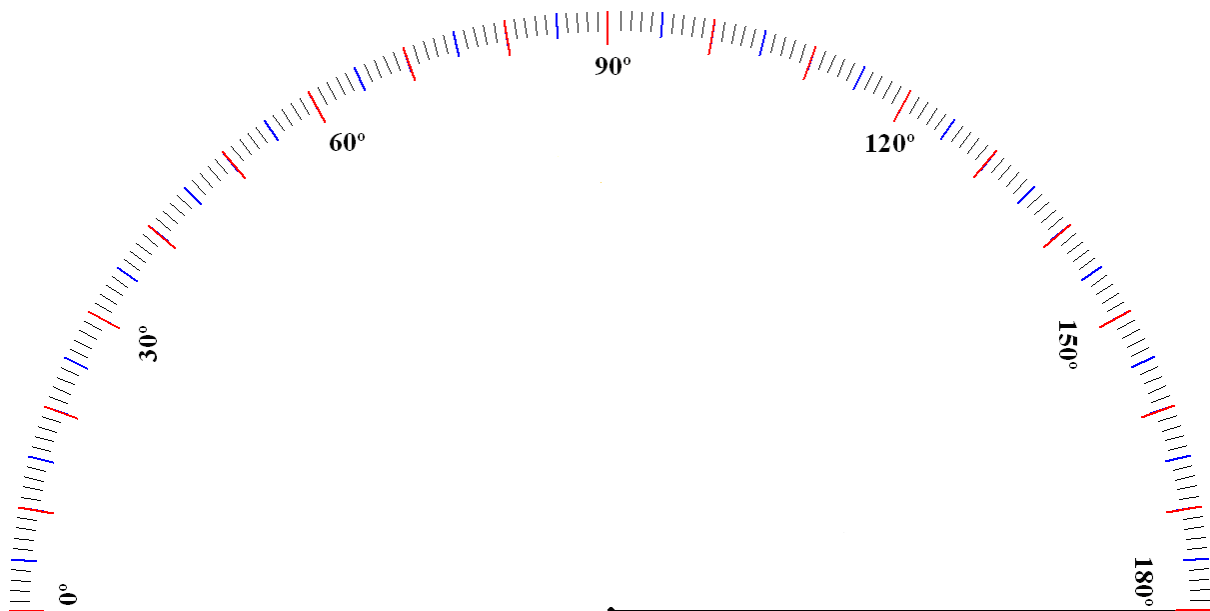


Fig. 8: Graduation of 180° to stick on the horizontal goniometer.

How is it used:

- If we want to measure the azimuth of a star we align the starting line of the semicircle in the North-South direction.
- The azimuth is the angle between the North-South line and the line through the center of the circle and the direction of the body.

Proposed exercises:

What is the position of the moon tonight?

Use the quadrant and the horizontal goniometer to calculate the height and azimuth of the moon. To study the motion of the moon at night, you can determine the two coordinates three times every hour. This way you can compare the motion of the moon with the stars in the sky.

The planisphere

We use star maps -which depend on the latitude- to recognize the constellations. We build one of them but we recommend extending it with a photocopier.

To build the planisphere: We will use a photocopy of the constellations of the sky in a "white" disc and will place into a holder depending on your latitude close to the equator.

Northern Hemisphere

For places in the northern hemisphere with *latitudes between 0 and 20 degrees* you should prepare two planispheres, one for each horizon. To build the northern horizon we cut the window of figure 9a by the continuous line corresponding latitude and fold it on the dotted line to form a pocket. We will place the star map of figure 10a inside. Now we have the planisphere of the northern horizon. We proceed analogously to build the planisphere of the southern horizon. Cutting and bending, as before, the window of figure 9b in placing inside the star map in figure 10a. We will use both planispheres as we are looking towards the horizon north or south.

When we wish to observe in the northern hemisphere with *latitudes between 30 and 70 degrees* it is enough to cut the window in figure 9e by the solid line and fold the dotted line to get a pocket where it will place the circle of stars that we cut above (figure 10a).

Southern Hemisphere

For places in the southern hemisphere with *latitudes between 0 and 20 degrees* we should prepare two planispheres, one for each horizon. At first we build the northern horizon. We cut the window of figure 9c by the continuous line corresponding latitude and fold it by the dotted line to form a pocket. We will place the star map of figure 10b inside. With this operation we have the planisphere of the northern horizon. We proceed analogously to build the planisphere of the southern horizon. Cutting and bending, as before, the window of figure 9d in placing inside the star map in figure 10b. We will use both planispheres as we are looking towards the horizon north or south.

When we wish to see in the southern hemisphere with *latitudes between 30 and 70 degrees* it is enough to cut the window in Figure 9f by the solid line and fold the dotted line to get a pocket where it will place the circle of stars that we cut above (figure 10b).

How to use:

- Place the date of the day when we will look in line with the observation time by rotating the circle of stars and use the world map looking at the sky in the direction indicated. The part of the sky that is visible in the sky is shown.
- Note: A planisphere is used as an umbrella. It is a map of the sky and you place it above your head to recognize constellations.

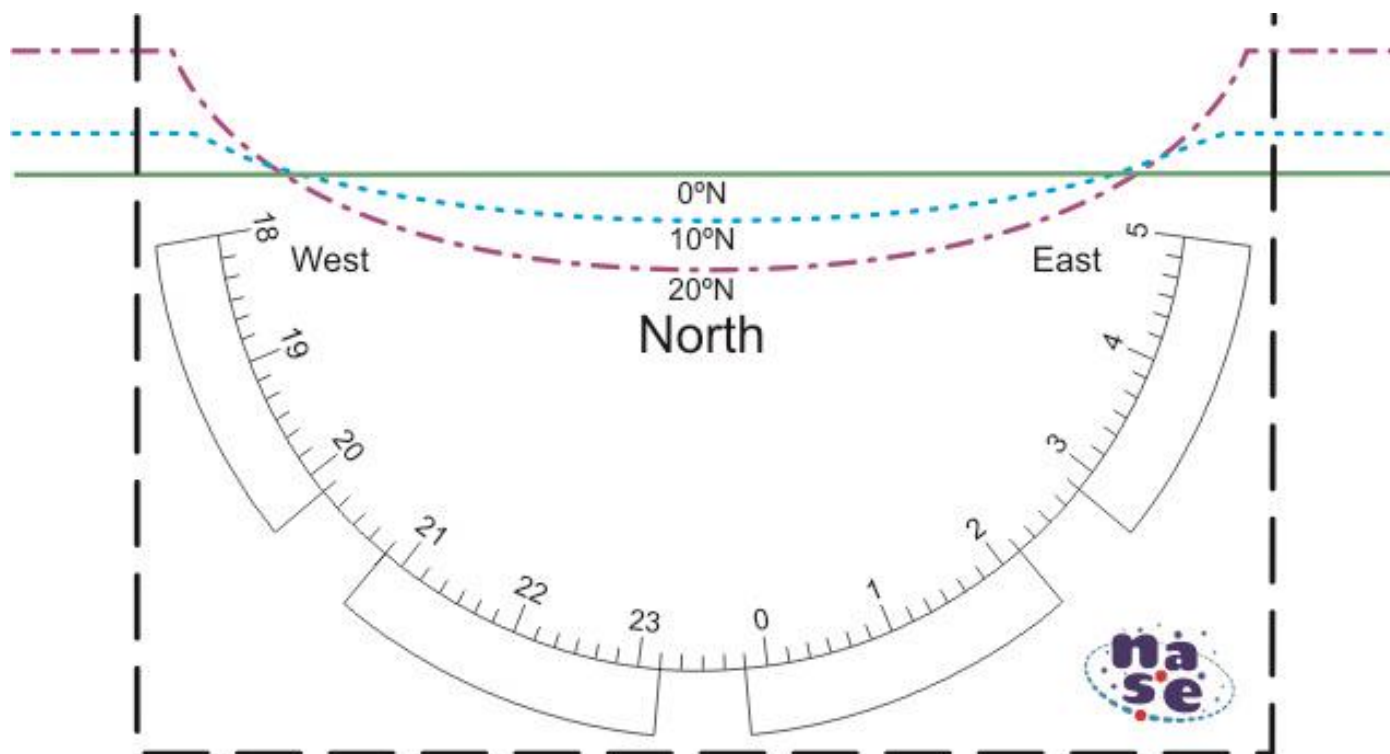


Fig. 9a: Pocket for the northern horizon in northern hemisphere (latitude 0, 10 and 20 North).

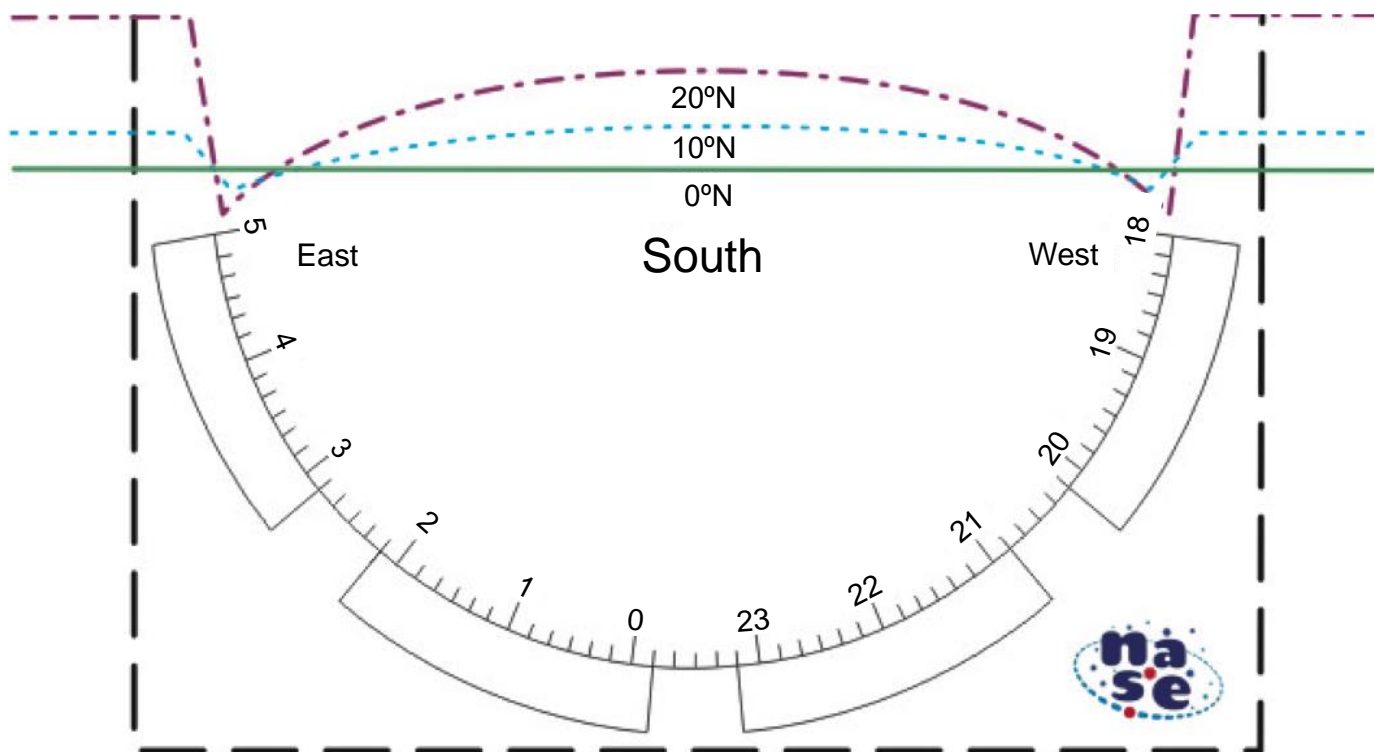


Fig. 9b: Pocket for the southern horizon in northern hemisphere (latitude 0, 10 and 20 North).

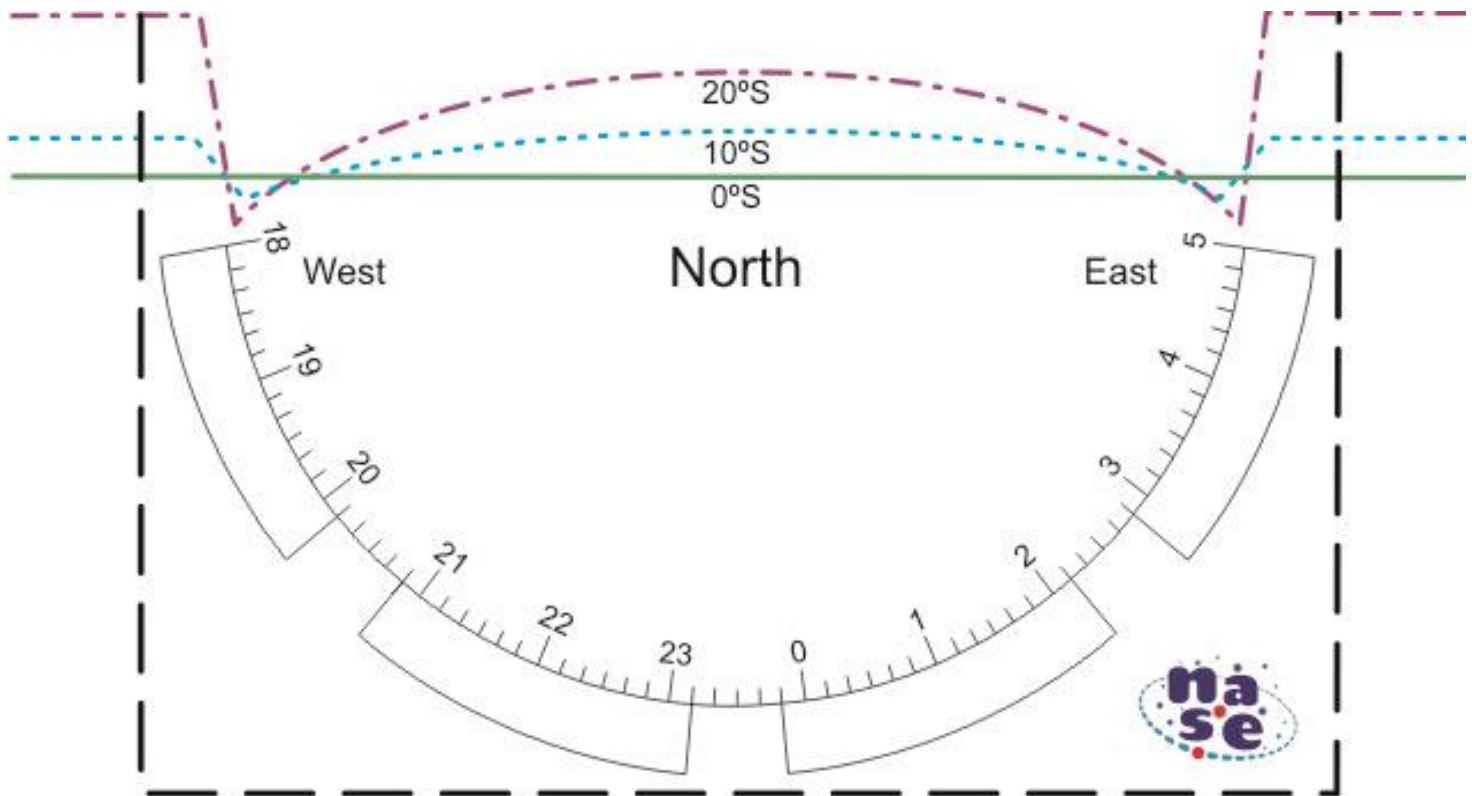


Fig. 9c: Pocket for the northern horizon in southern hemisphere (latitude 0, 10 and 20 South).

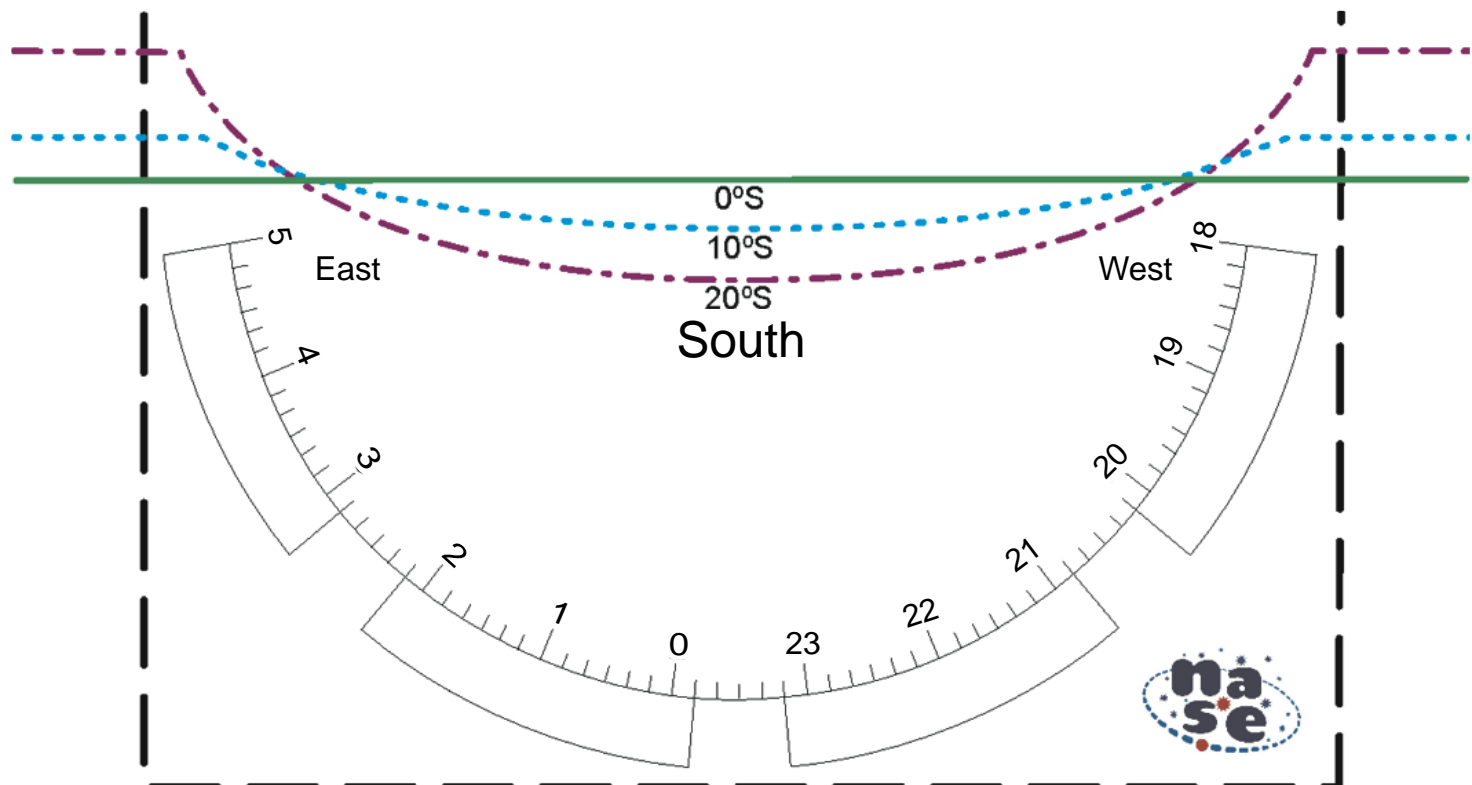


Fig. 9d: Pocket for the southern horizon in southern hemisphere (latitude 0, 10 and 20 South).

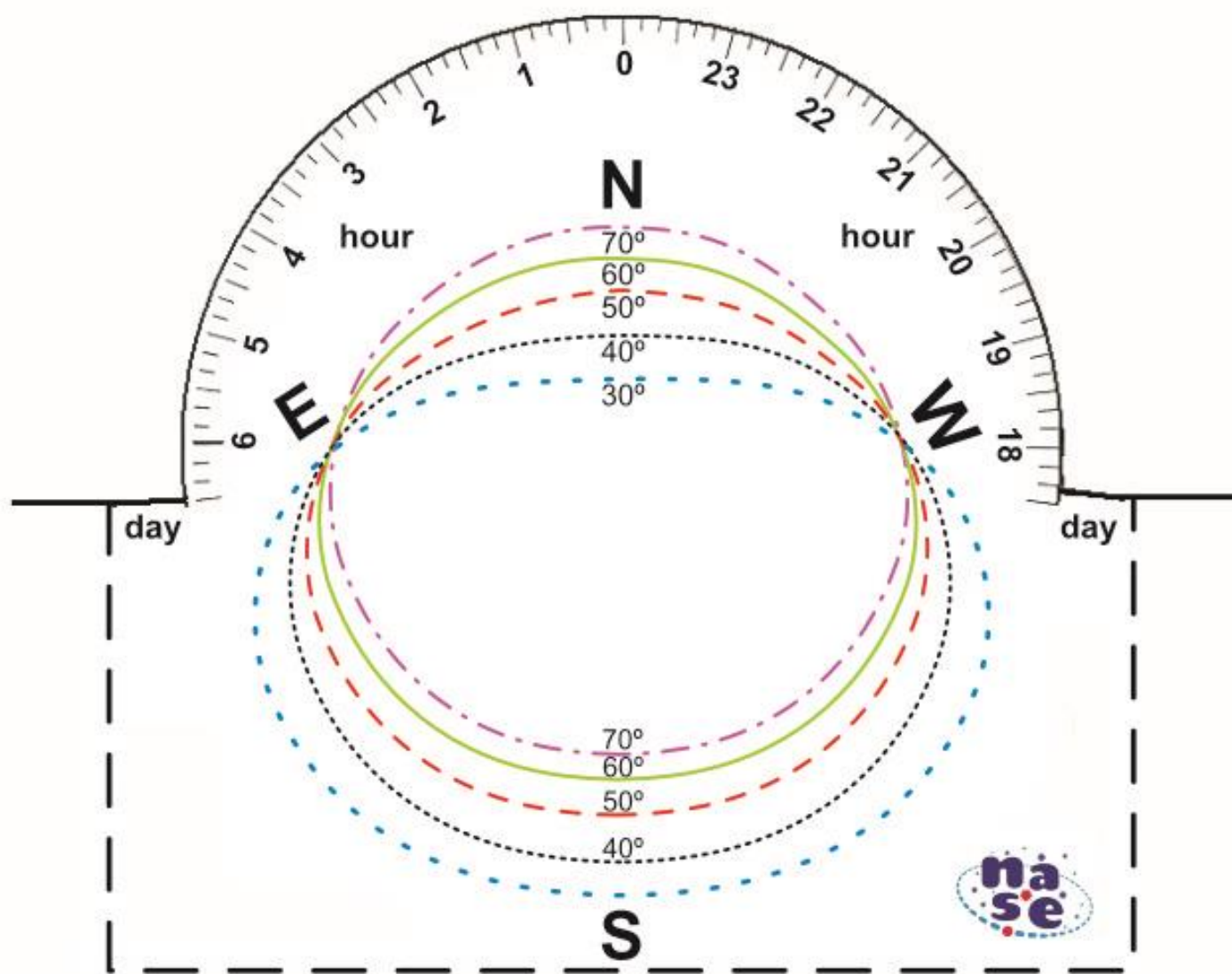


Fig. 9e: Pocket for both horizons in northern hemisphere. Latitudes 30, 40, 50, 60 and 70 North.

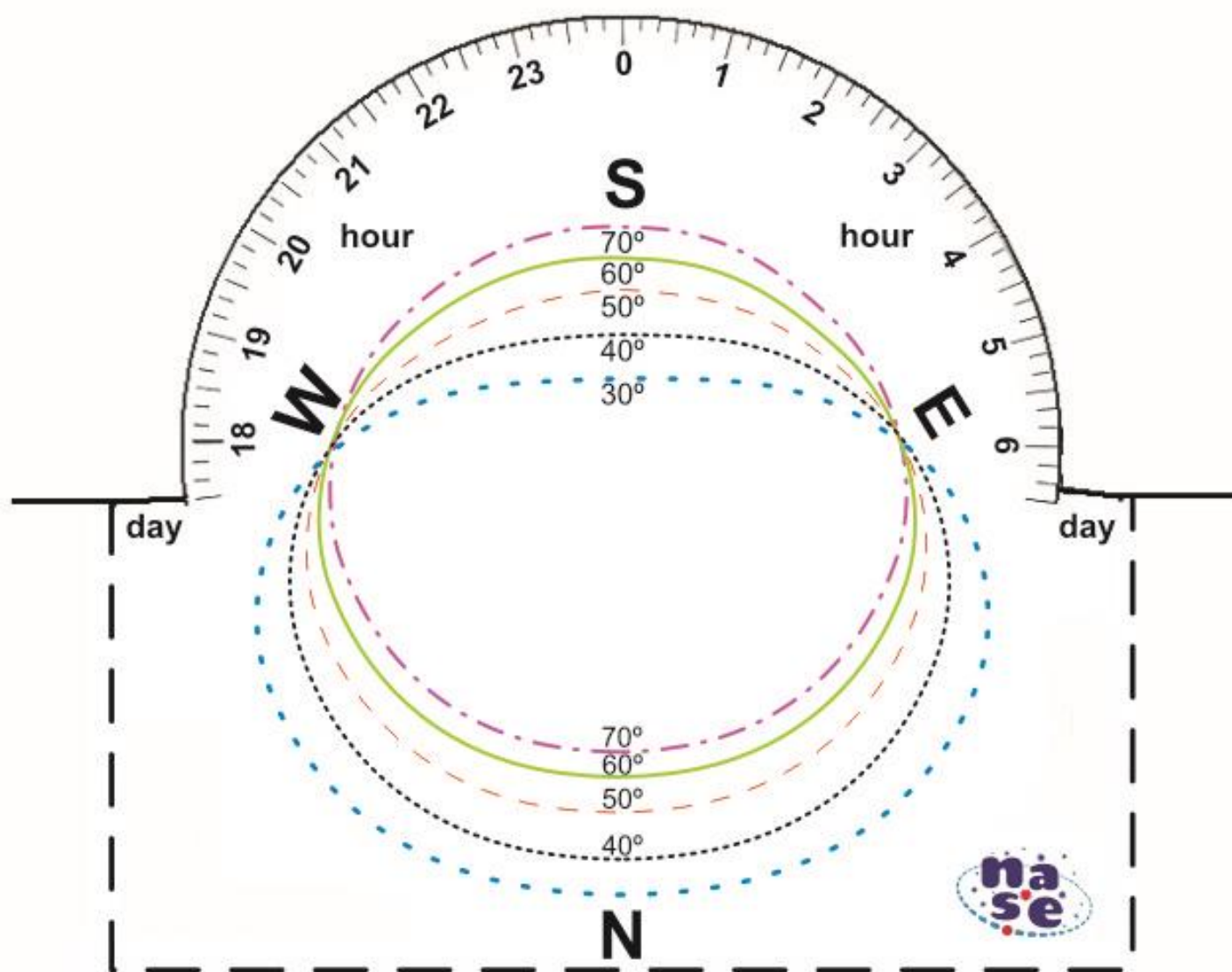


Fig. 9f: Pocket for both horizons in southern hemisphere. Latitudes 30, 40, 50, 60 and 70 South

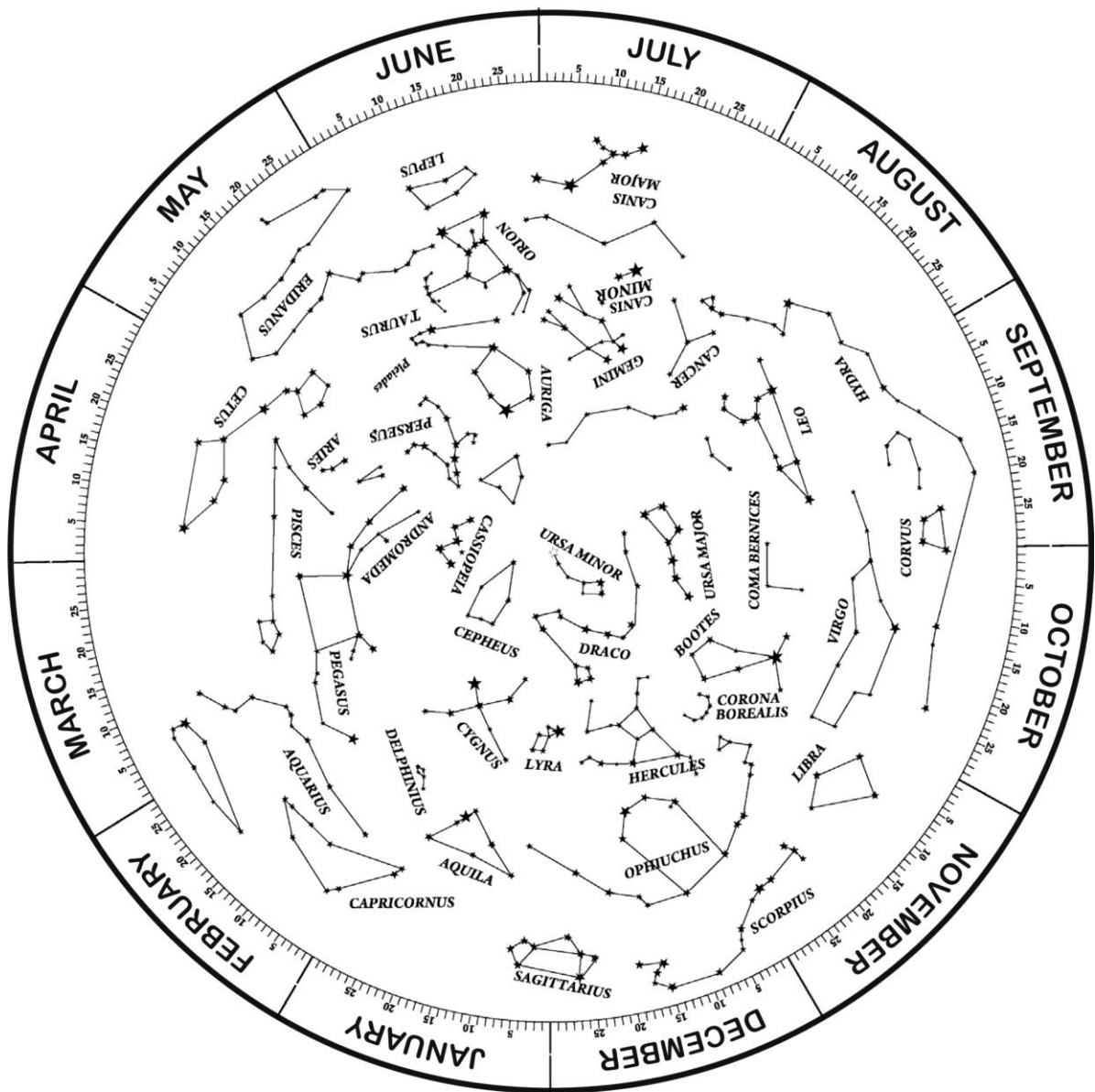


Fig. 10a: The disk or stellar map that is placed inside the pocket. Northern Hemisphere.

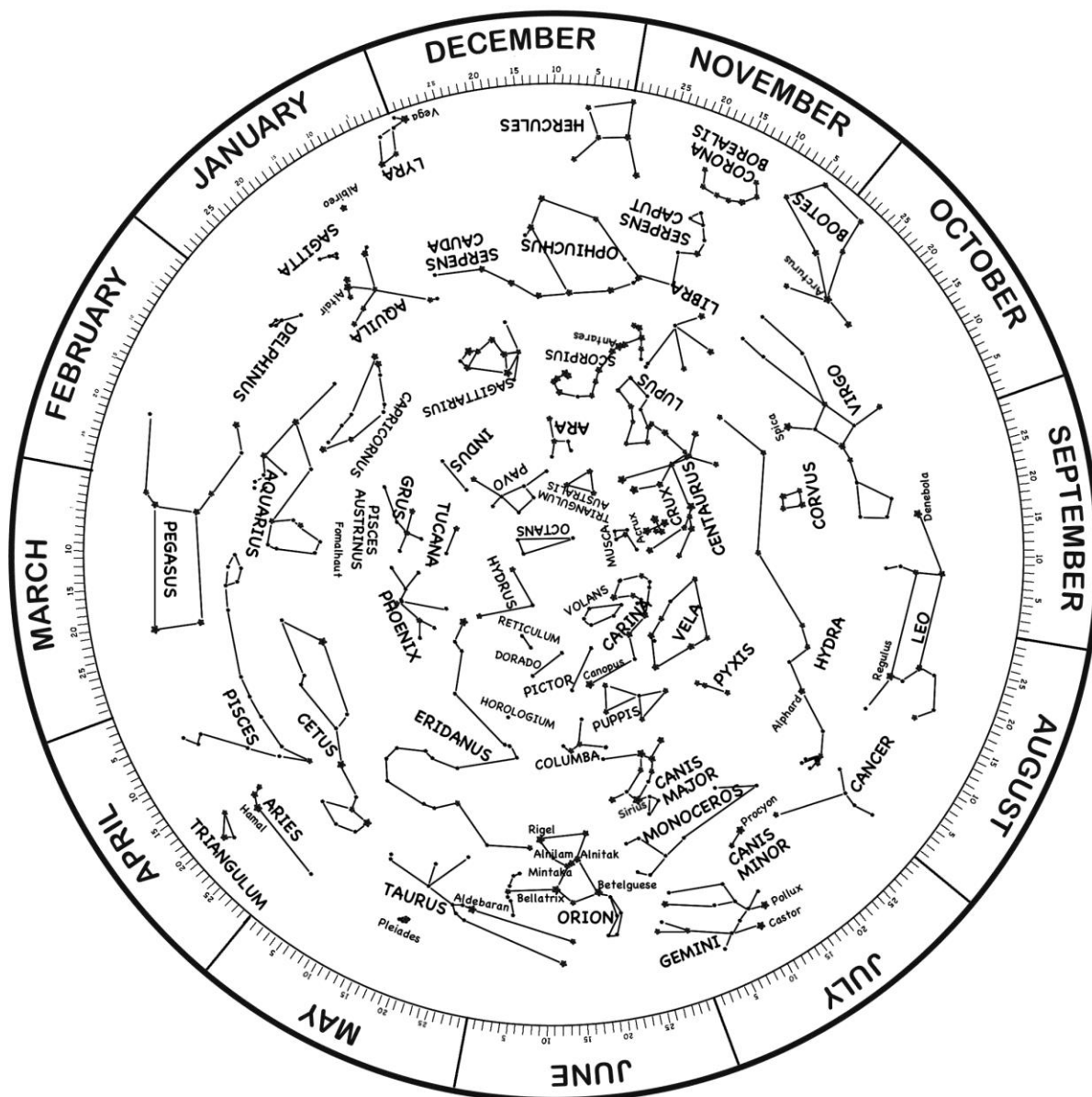


Fig. 10b: The disk or stellar map that is placed inside the pocket. Southern Hemisphere.

Proposed exercises:**Which sky can we see tonight?**

Using the planisphere you've made for the latitude of your school, turn the stellar disc until today's date coincides with the time you plan to go out and observe.

Note that the planisphere is a "stellar map" and you have to lift it over your head "as an umbrella" (it is not a map of your city!).

Spectroscopy

By passing the light of the sun through this sensitive instrument, the student will be able to visualize the spectral decomposition of the light. This is a simple way for the students to observe the stellar spectrum with an instrument constructed with their own hands.

How to make the spectroscope: Paint the interior of a large matchbox (of the size typically used in a kitchen). Make a longitudinal cut (figure 11b) through which the observer can view the spectrum. Cut a damaged (or otherwise unusable) CD into 8 equal parts, and place one of the pieces inside the box, on the bottom, with the recordable surface facing up. Close the box, leaving only a small section open, opposite from where you constructed the viewing slit.

How to use it:

- Orient the matchbox so that the sunlight falls through the open section, and observe through the viewing slit (figure 11a)
- Inside the matchbox, you will see the sunlight split into the colors of its spectrum.

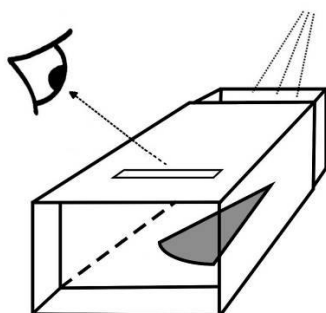


Fig. 11a and 11b: How to use the spectroscope.

Proposed exercises:

Compare the solar spectrum with a fluorescent or other lamps that are in school. *You will be able to observe variations that appear in the spectrum depending on the type of lamp that you're viewing.*

Map of the Moon

It's good to include in your briefcase a simplified version of a lunar map that includes the name of the seas and some of the craters that can be seen with binoculars or with small telescopes.

To build it: You need a square piece of cardboard (about 20x20 cm) (figures 12 or 13).

How to use it?:

- Be aware that the orientation will change depending on if you are using the naked eye, if you are using binoculars or a telescope (inverted image), and whether you are watching from the Northern or Southern Hemisphere. It is easiest to begin by identifying the seas, verify that the position is correct and then continue to identify other lunar features.

Proposed exercise:

Which is the Tycho crater? Look at the moon when it is more than half illuminated and identify in the central zone a crater with a large system of rays (lines that leaves the crater and head in all directions across the surface of the satellite).

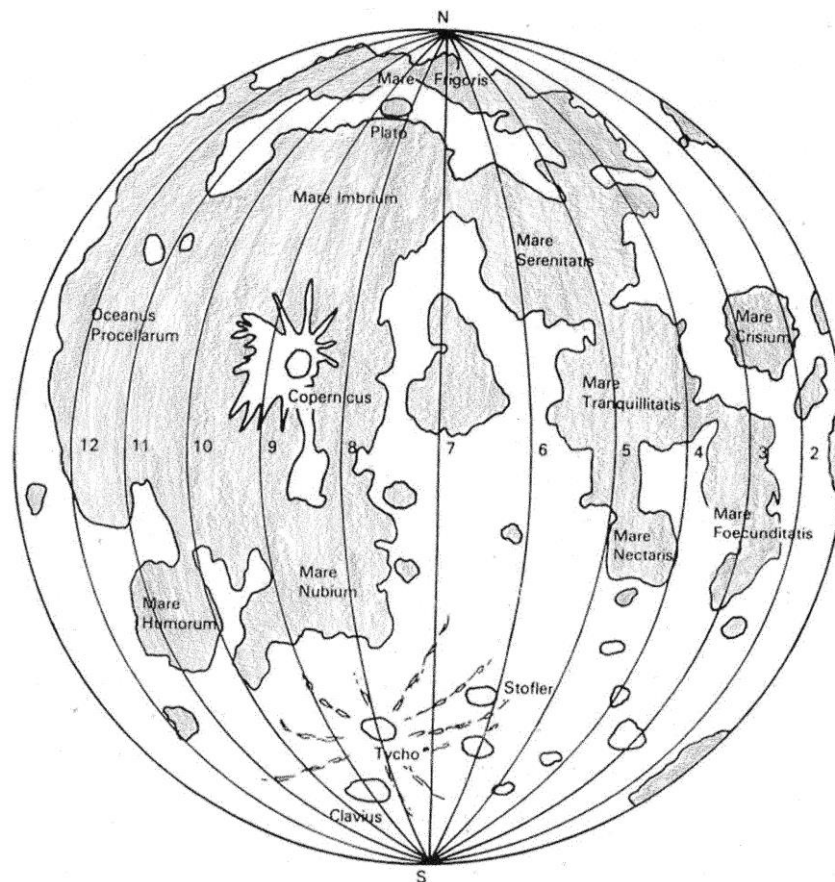


Fig. 12: Schematic map of the Moon.

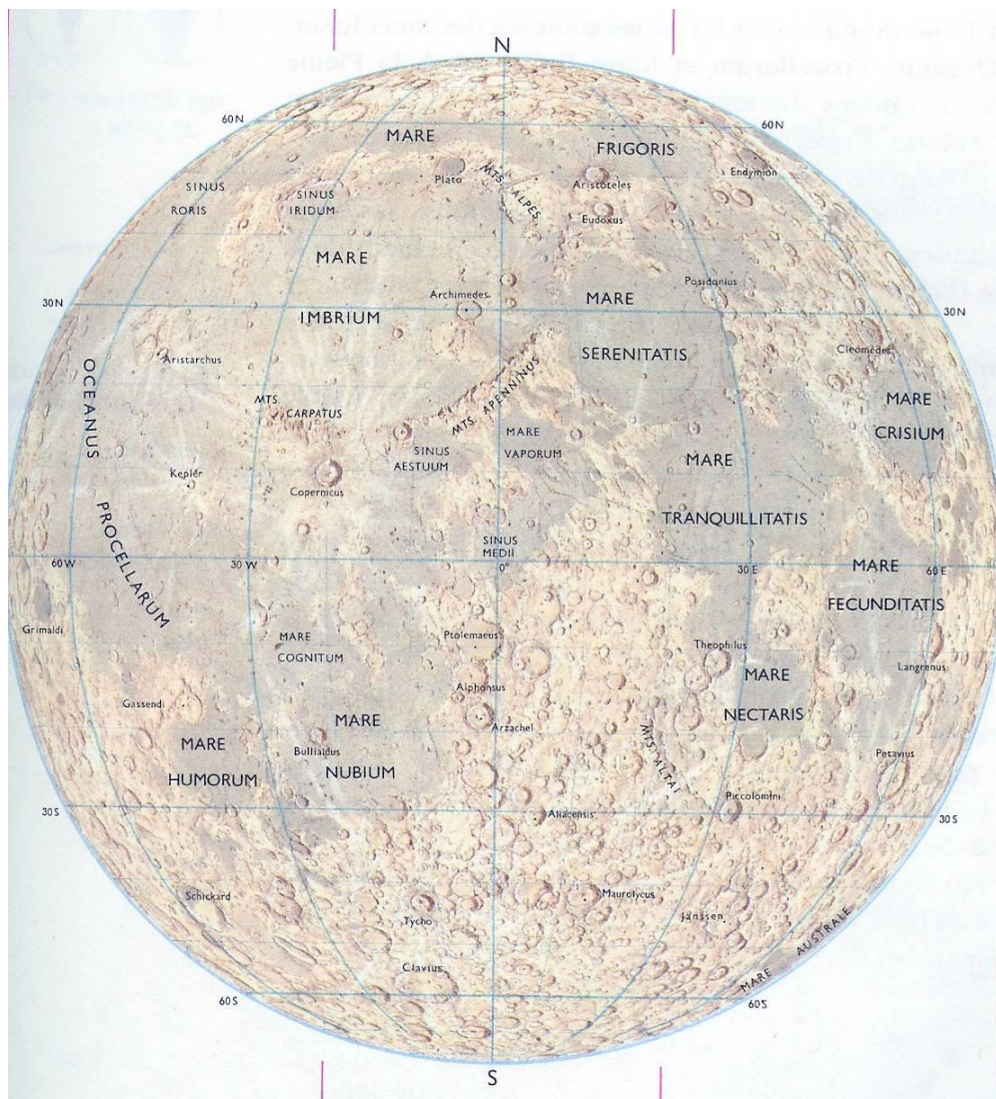


Fig. 13: Simplified map of the Moon.

Organizing your Briefcase

Place a paper bag with a sheet on the upper side of the box open (figure 14) to store the planisphere, the map of the Moon, the sundial, etc.

In the deep part of the box place the instruments so that they can not move, using clips, pins, and small belts. The screw of the quadrant should be set around the center because the suitcase contains delicate instruments and can be balanced when handle it. A group of students proposed putting a list on the outside of the bag indicating its contents, so we would be sure to have gathered everything at the end of the activity. In addition, of course, labeled with your name and any decorations you can think of, in order to customize the suitcase.



Fig. 14: The suitcase

Conclusions

Observing how the sky moves during the night, the day and throughout the year is a must for young astronomers. With these kind of projects, students will be able:

- To gain confidence with the measures;
- To take responsibility for their own instruments;
- To develop their creativity and manual ability;
- To understand the importance of systematic collection of data;
- To facilitate the understanding of more sophisticated instruments;
- To recognize the importance of observation with the naked eye, then and now.

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