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A stellar demonstrator

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Abstract

The main purpose of the stellar demonstrator is to help explain the movement of stars. In particular, students have difficulties understanding why, if they are living in the Northern Hemisphere, they may observe starts in the Southern Hemisphere, or why circumpolar stars are not the same in different parts of Europe. Using the demonstrator, these questions and others have a simple answer.

[M] This article features online multimedia enhancements

Introduction

In our latitudes there are constellations which rise and set, but in other places on the Earth these constellations may be invisible or circumpolar. We can discuss these topics with students by means of a demonstrator (Ros 2008). Templates are available online at stacks.iop.org/physed/44/356.

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The stellar demonstrator: why there are invisible stars

Depending on the students' ages, they can understand fairly easily which stars are circumpolar in the place where they live, but it is much more difficult to discover which of them are circumpolar in other places. If we ask whether one specific star, e.g. Sirius, rises and sets in Stockholm or Athens, they do not know the answer. We will use the star demonstrator to study the different kinds of stars depending on the latitude of the place of observation.

The main goal of the demonstrator

The main objective is to discover which constellations are circumpolar, which rise and set, and which are invisible at specific latitudes. If we observe at a latitude of around 45° N, it is clear that we can see quite a lot of stars from the Southern Hemisphere rise and set every night (figure 1).

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Table 1. Constellations that appear in the stellar demonstrator.

Constellation	Maximum declination	Minimum declination
Ursa Minor	+90°	+70°
Ursa Major	+60°	+50°
Cygnus	+50°	+30°
Leo	+30°	+10°
Orion and Sirius	+10°	−10°
Scorpio	−20°	−50°
Southern Cross	−50°	−70°

In our case, the demonstrator includes some constellations that have been drawn with different declinations (without considering their right ascensions, because in this case it is not our objective). It is a good idea to use constellations that are well known to students and with different right ascensions, in order to have constellations visible during different months of the year (figures 2 and 4).

When selecting the constellation to be drawn, only the bright stars were utilized to identify the shape of each constellation. We do not use constellations which are on the same meridian, because we decided to choose constellations that

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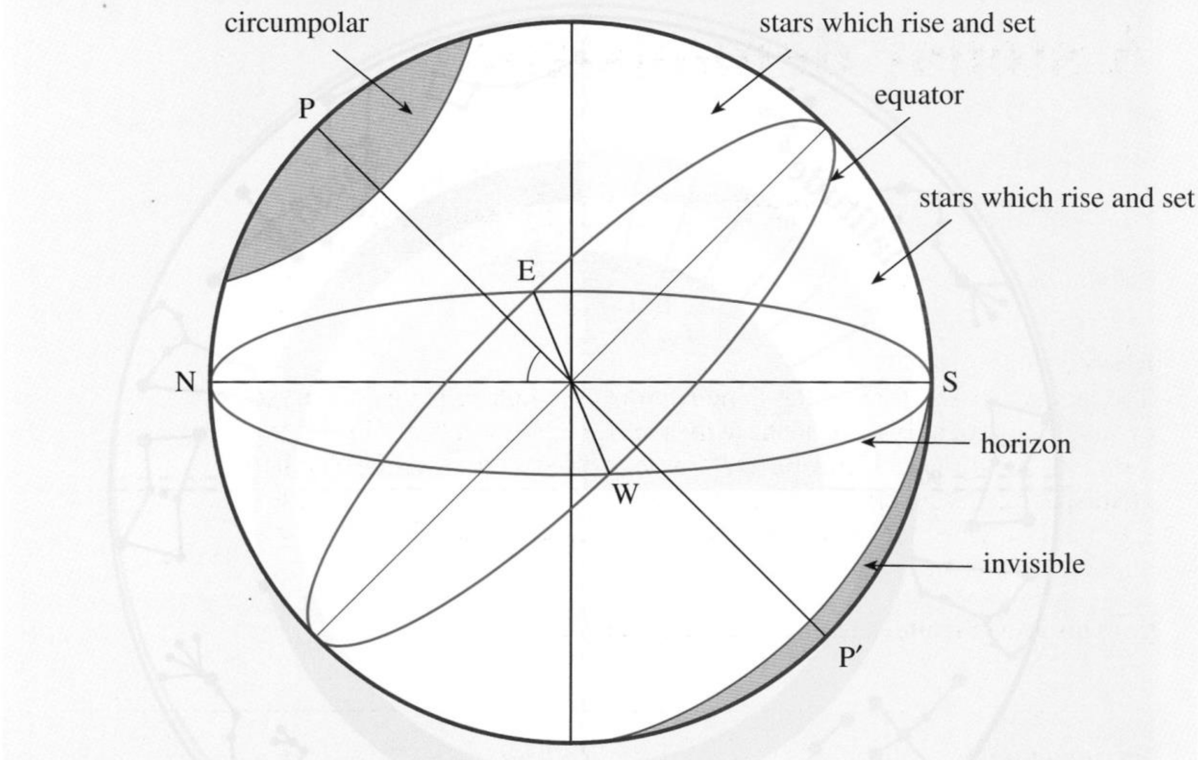

Figure 1. Three different kinds of stars (for each latitude): circumpolar, stars which rise and set, and invisible stars.

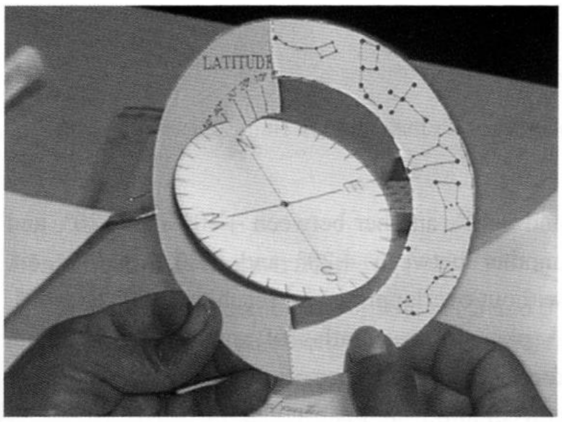

Figure 2. Example of a demonstrator for the Northern Hemisphere using table 1.

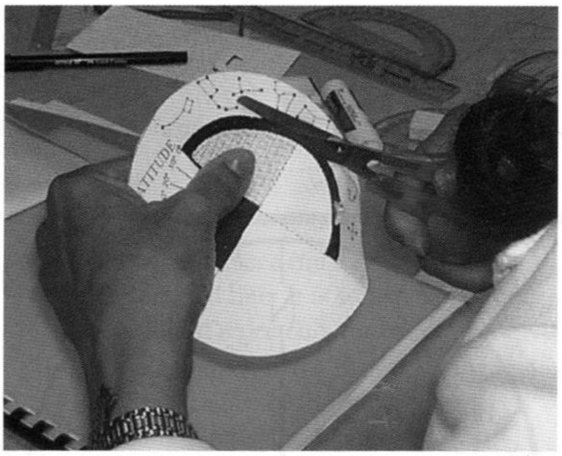

Figure 3. Making the stellar demonstrator.

would be well known to students who sometimes observed the sky (table 1).

If you are interested in doing this study for each season, you can make four different demonstrators, one for each season. For example, you can use constellations which have different declinations, but always with their right ascension between 21 and 3 h for the autumn, between 3 and 9 h for the winter, between 9 and 14 h for spring, and finally from 14 to 21 h for the summer.

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If we decide to consider only one season, it may be difficult to select one constellation between +90° and +60°, another between +60°

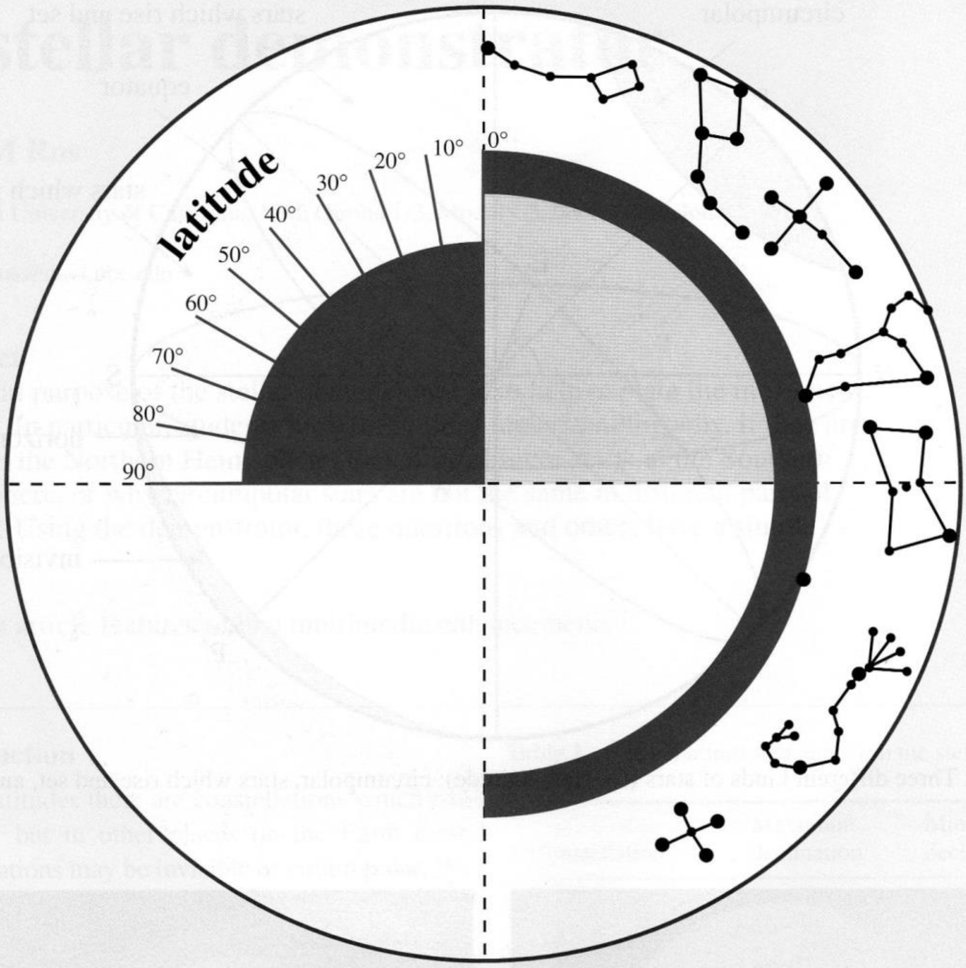

Figure 4. The main part of the stellar demonstrator for the Northern Hemisphere.

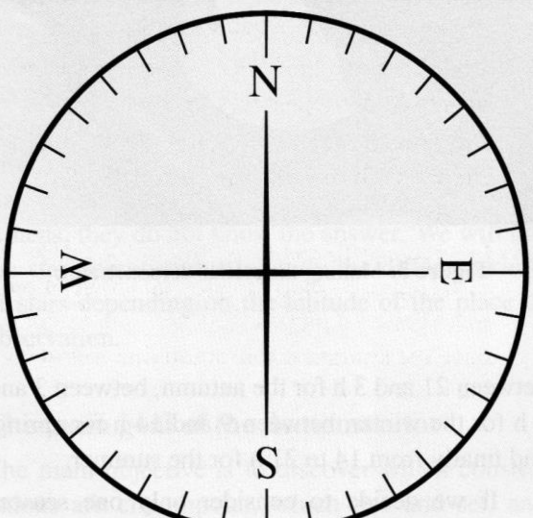

Figure 5. The horizon disc.

and +40°, another between +40° and +20°, and another between +20° and −20°, and so on, without overlapping, and reaching −60° to −90°. A planisphere or atlas of stars will be enough for extracting information about the possible constellation so that it can be used with their right ascensions and declinations. If we also want to select constellations that are well known to students, with a small number of bright stars which are big enough to cover the entire meridian, it may be difficult to achieve our objective. As the whole sky does not have the same kinds of constellations (big, well known and bright) during the entire year, it may be better to make only one demonstrator to consider all the different right ascensions at the same time.

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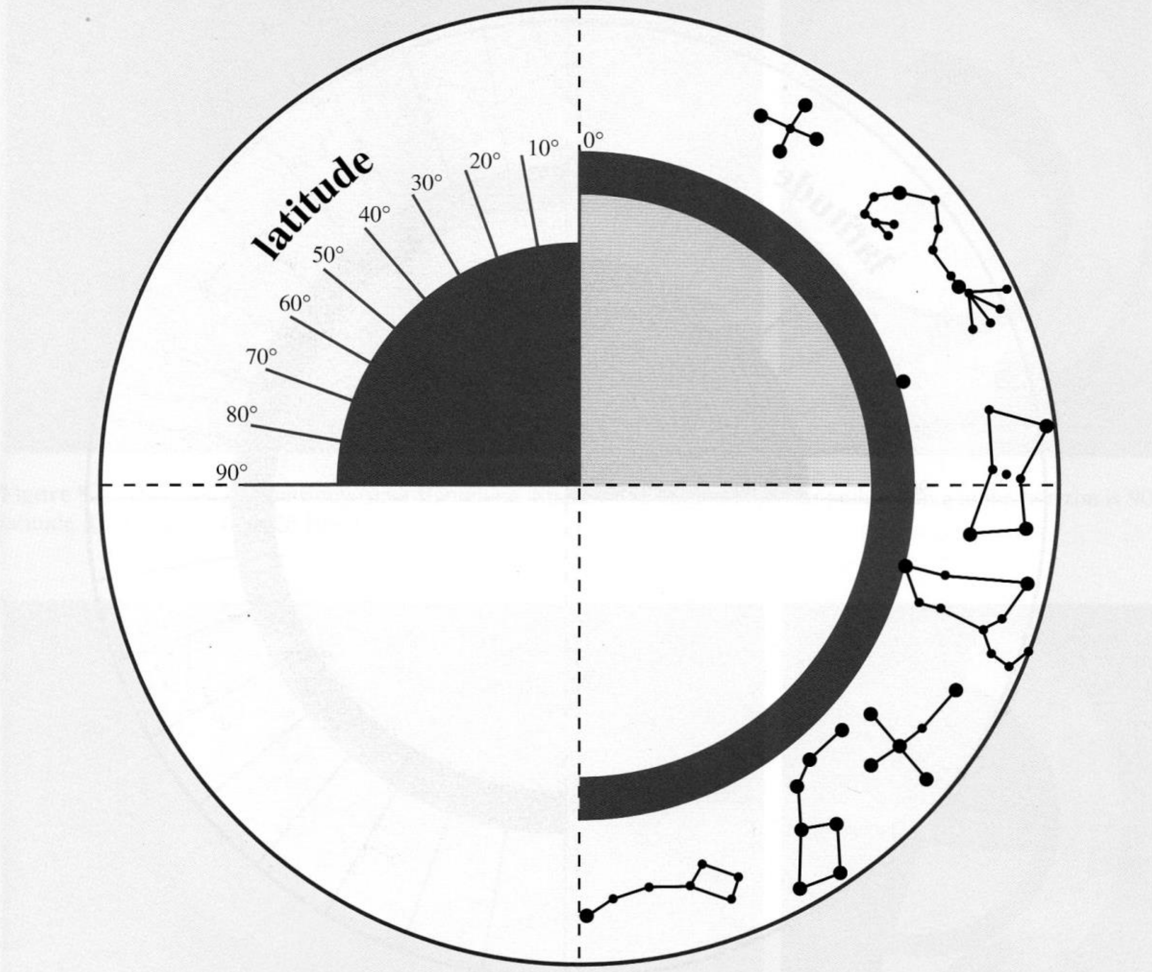

Figure 6. The main part of the stellar demonstrator for the Southern Hemisphere.

Making the demonstrator

To obtain a sturdy demonstrator (figures 2 and 3), it is a good idea to glue both pieces of cardboard before cutting. It is also a good idea to construct another one twice as big which can be used for teaching.

We begin with the demonstrator for the Northern Hemisphere. The instructions for making it are as follows.

(a) Make a photocopy of figures 4 and 5 on cardboard.

(b) Cut both pieces along the continuous line (figures 4 and 5).

(c) Remove the black area from the main piece (figure 3).

(d) Fold the main piece (figure 4) along the straight dotted line. It is sometimes a good idea to fold it repeatedly for easier use.

(e) Cut a small notch in the N of the horizon disc (figure 5). It must be big enough for the cardboard to pass through it.

(f) Glue the north-east quadrant of the horizon disc (figure 5) onto the grey quadrant of the main piece (figure 4). It is very important to have the straight north–south line following the double line of the main piece and the cardinal point W appearing at latitude 90°.

(g) When we introduce the mark N of the horizon disc (figure 5) inside the latitude zone, the disc must stay perpendicular to the main piece.

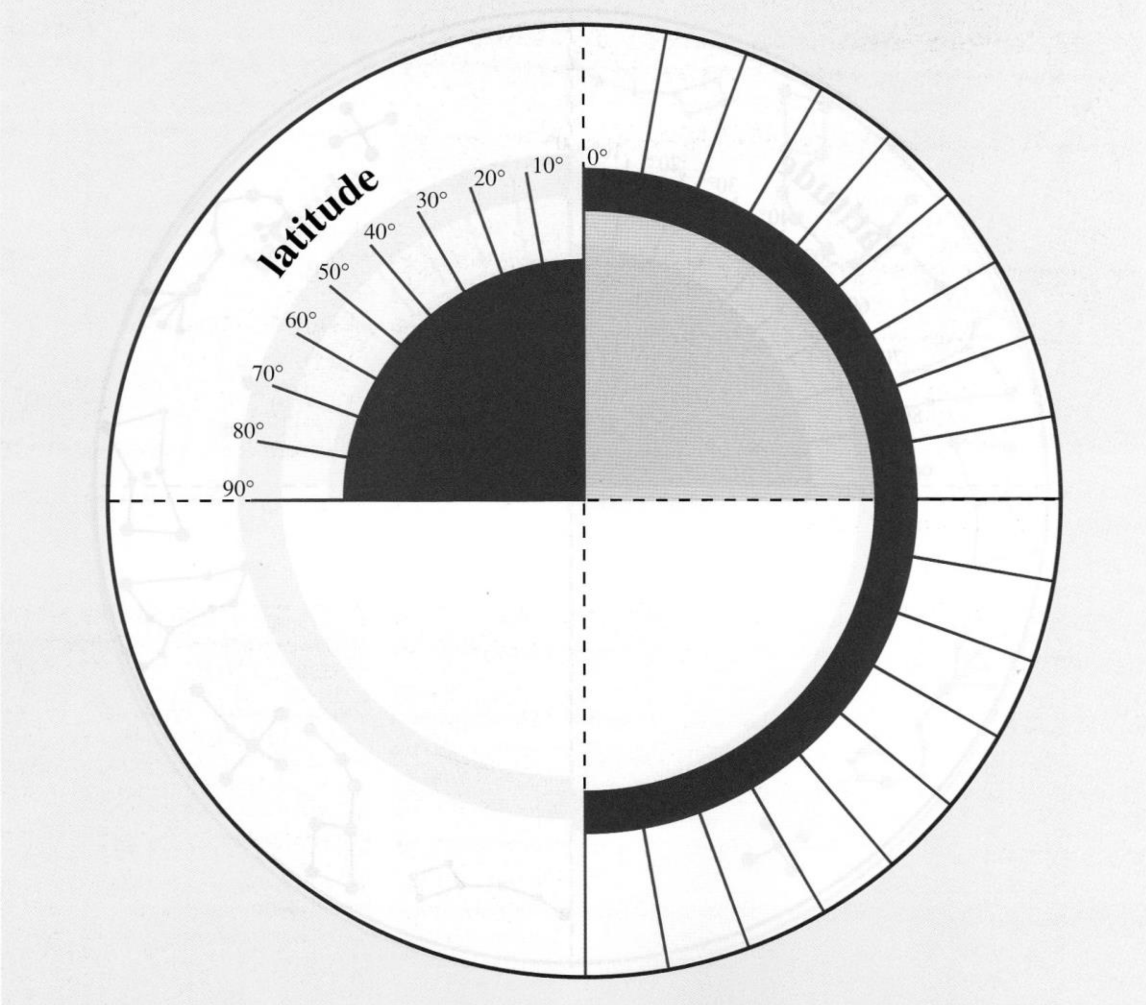

Figure 7. The main part of the stellar demonstrator for the Northern or Southern Hemispheres.

(h) It is very important to glue the different parts carefully to obtain maximum precision.

In order to produce a demonstrator for the Southern Hemisphere, we must change some aspects of the previous instructions. We will change figure 4 for figure 6, cut the small notch in the S of horizon disc and glue the south-west quadrant of figure 5 onto the grey part of figure 6.

Everybody can choose which stellar demonstrator they want to make, depending on their hemisphere. You can select the constellations following different criteria. For instance, you can include constellations visible for only one season, or constellations visible for only one month, etc. In this case you must consider only the constellation with its right ascension between two specific values. You have to draw the constellations with their declination values on figure 7. Take into account that each sector corresponds to 10°.

Uses of the stellar demonstrator

To start to use the demonstrator you have to enter the latitude of the place of observation that you have selected. We will travel over the Earth's surface on an imaginary trip using the demonstrator.

Use your left hand to hold the main piece of the demonstrator (figure 4 or 6 depending on the hemisphere under consideration) by the blank area (below the latitude quadrant). Select the latitude and move the horizon disc until it shows the latitude chosen. With your right hand, move

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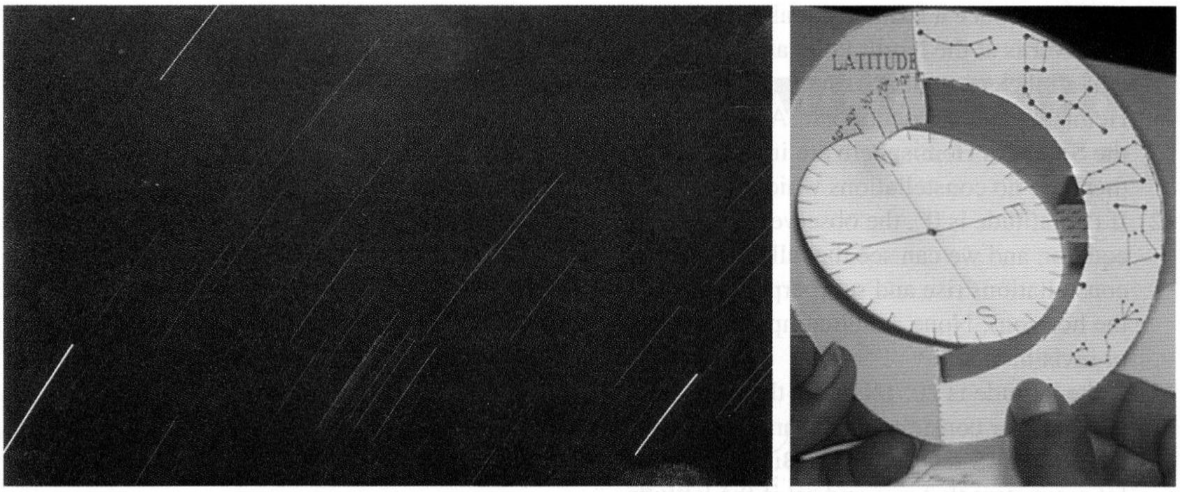

Figure 8. Stars rising in Montseny (near Barcelona, Spain). The angle of the star path relative to the horizon is 90° latitude. (Photograph by R M Ros.)

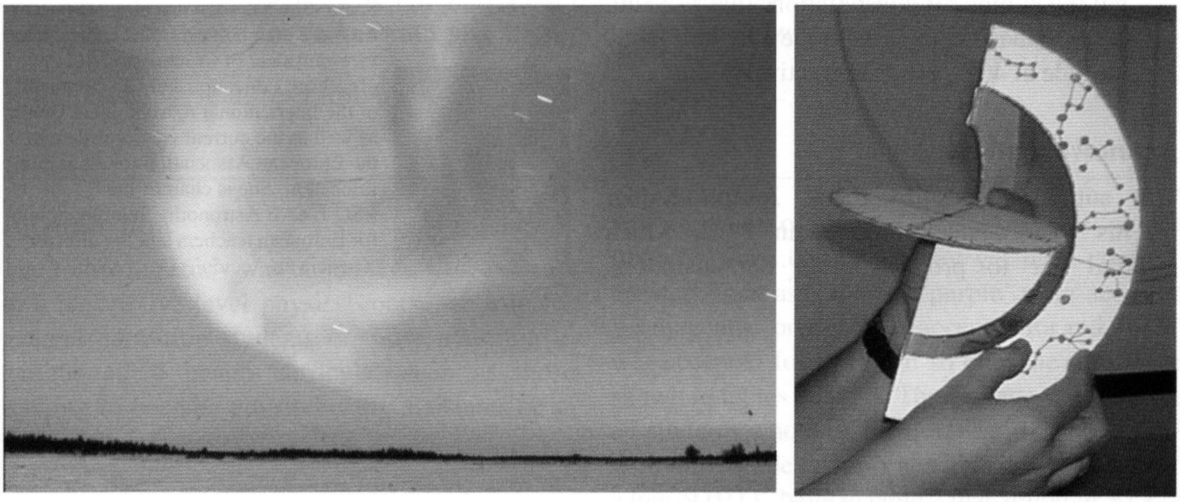

Figure 9. Stars setting in Enontekiö in Lapland (Finland). The angle of the star path relative to the horizon is 90° latitude. Observe that the star paths are shorter than in the previous photograph because the aurora borealis causes a reduction in the exposure time. (Photograph by Irma Hannula, Finland.)

the disc with the constellations from right to left several times. You can observe what constellations are always on the horizon (circumpolar), what constellations rise and set, and which of them are always below the horizon (invisible; figures 8 and 9).

Star path inclination relative to the horizon

Using the demonstrator it is very easy to observe how the angle of the star path relative to the horizon changes depending on the latitude (figures 8 and 9).

If the observer lives on the equator (latitude 0°) this angle is 90°. On the other hand, if the observer is living at the North or South Pole (latitude 90° N or 90° S), the star path is parallel to the horizon. In general, if the observer lives in a city at latitude L, the star path inclination on the horizon is $90° - L$ every day.

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In figures 8 and 9 we can verify this. The photograph in figure 9 was taken in Lapland (Finland) and the one in figure 8 in Montseny (near Barcelona, Spain). Lapland is at a higher latitude than Barcelona, but the star path inclination is less.

Using the demonstrator in this way, the students can easily complete the different activities listed below.

(1) If we introduce a latitude equal to +90°, the observer is at the North Pole, and we can see that all the constellations in the Northern Hemisphere are circumpolar. All the ones in the Southern Hemisphere are invisible and there are no constellations which rise and set.
(2) If the latitude is 0°, the observer is on the equator, and we can see that all the constellations rise and set (perpendicular to the horizon). None are circumpolar or invisible.
(3) If the latitude is 20° (N or S), there are fewer circumpolar constellations than if the latitude is 40° (N or S respectively). But there are a lot more stars that rise and set if the latitude is 20° instead of 40°.
(4) If the latitude is 60° (N or S), there are a lot of circumpolar and invisible constellations, but the number of constellations that rise and set is reduced compared to the case at a latitude at 40° (N or S respectively).

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