

THE CONSTELLATIONS OF THE ZODIAC

G. Iafrate, M. Ramella
INAF - Osservatorio Astronomico di Trieste

Information and contacts: <http://vo-for-education.oats.inaf.it> - iafrate@oats.inaf.it

Within this use case you learn about the constellations of the Zodiac, i.e. those crossed by the apparent path of the Sun during the year. Together with some characteristics the orbital motion of the Earth, in this use case you also find a short excursion into history of astronomy. The use case also introduces the precession of the equinoxes.

If used in the classroom this basic use case requires only a brief introduction from the teacher. Pupils will soon be able to investigate the zodiacal constellations on their own.

1. Introduction

We hear often about the zodiac, but probably we do not know what it means to be, as an example, in the sign of Scorpius, or if November is really the correct month for Scorpius.

The zodiac originated in the apparent yearly path of the Sun on the sky: as the earth moves around the Sun, the Sun appears to drift among the zodiac constellations along a path called ecliptic. This use case helps us, using Stellarium, to understand the historical origins of the zodiac, how the Sun moves along the constellations of the zodiac and what is the link between zodiacal signs and constellations.

2. The motion of the Sun

The night sky changes throughout the year because of Earth's revolution around the Sun.

As we orbit the Sun over the course of the year, the Sun appears to gradually move eastward along the ecliptic (the apparent path of the Sun and the planets in the sky), completing one circuit every year. Along the ecliptic we found the constellations of the zodiac. Tradition places 12 constellations along the zodiac. The Sun's apparent location along the ecliptic determines which constellations we see at night. For example (look at fig. 1), in late august if you look in the direction of the Sun you find the constellation of Leo. But pay attention: in late august you can not see Leo, because

it moves with the Sun through the daytime sky and we can not see the Sun and the stars at the same time.

Here the Solution at the problem: we can see the opposite constellation, with respect the position of the Sun on the ecliptic, Aquarius, all night long. Six

month later, in February, we see Leo at night while Aquarius is above the horizon only in the daytime.

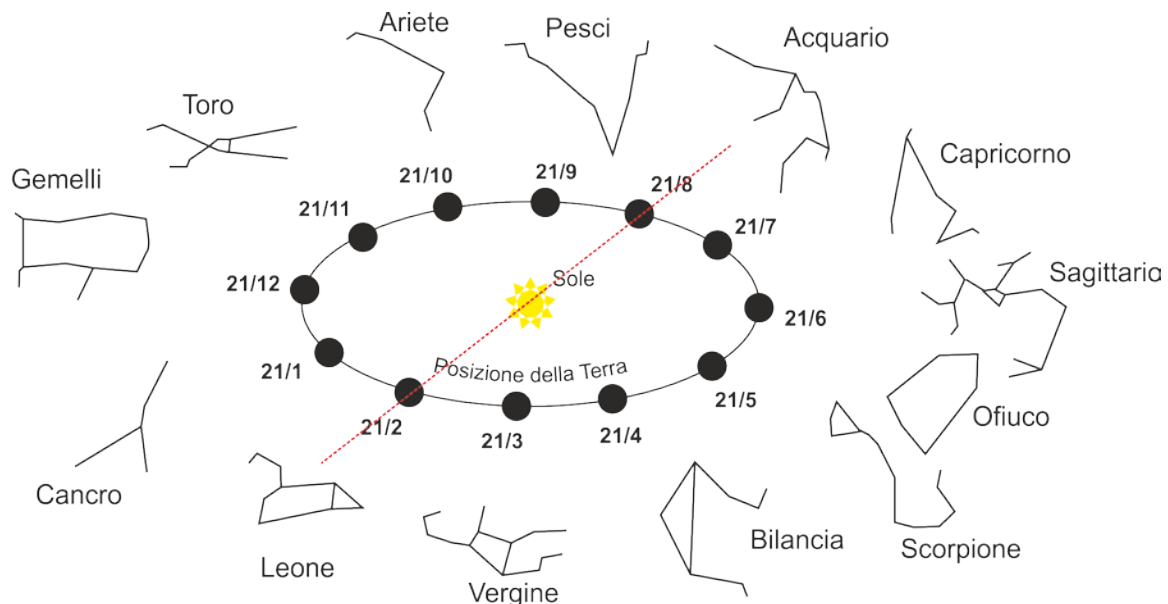


Fig. 1: The orbit of the Earth around the Sun with the background of the zodiac constellations.

3. History of the zodiac

The division of the ecliptic into the zodiacal signs originates from the Chaldean people (Babylonians) around 500 BC. This division of the ecliptic into twelve equal zones of celestial longitude ends up being the first known celestial coordinates system.

The Babylonian calendar assigned each month to a sign, beginning with the position of the Sun at vernal equinox (March 21) which, at the time, was in the Aries constellation.

For this reason the first constellation of the zodiac is still called "Aries" even after the vernal equinox has moved away from the Aries constellation due to the precession of the Earth's axis of rotation. It is important to distinguish between the zodiacal signs and the constellations

associated with them. The zodiacal signs are an abstraction from the physical constellations designed to represent exactly one twelfth of the full ecliptic circle each (30°), that is the longitude traversed by the Sun in about 30.4 days.

The astronomical constellations vary widely in size. For example, Virgo covers five times as much ecliptic longitude as Scorpius. The actual boundaries of all 88 official constellations in the sky were established by the International Astronomical Union (IAU) in 1930. According to this division the path of the ecliptic now passes through thirteen constellations: the twelve traditional zodiacal constellations plus Ophiuchus, the bottom part of which is located between Scorpius and Sagittarius. Ophiuchus is an anciently recognized

constellation, but not historically referred to as a zodiac constellation.

4. Precession of equinoxes

The equinoxes are the two points where the ecliptic crosses the celestial equator. When the Sun is in these points (vernal and autumnal equinoxes) we have on the Earth the duration of day and night equal. The precession of equinoxes is a motion of the Earth that gradually changes the orientation of the Earth's rotation axis in space.

The rotation axis moves like a spinning top because of the not perfectly spherical shape of the Earth and of the gravitational influence of the Sun and the Moon.

The result is a precession motion that takes about 26000 years to complete a cycle. Due to this motion the position of stars, constellations and equinoxes change gradually.

The zodiacal year begins at the vernal equinox, that is the point where the ecliptic intersects the celestial equator.

The precession of equinoxes caused the zodiacal signs, originally matching the respective constellations, to be now shifted of about 30 degrees. As a result, the zodiacal signs are off by nearly a month from the actual positions of the Sun among the constellations.









5. Stellarium


Stellarium is a free software that transforms a home computer in a planetarium. It calculates the positions of Sun and Moon, planets and stars, and draws the sky how it would be seen from an observer anywhere on the Earth and at any epoch. Stellarium can also draw the constellations and simulate astronomical phenomena such as meteor showers and solar or lunar eclipses.

Stellarium may be used as an educational tool for kids of all ages, as an observational aid for amateur astronomers wishing to plan an observing night, or simply to explore the sky (it is fun!). Stellarium shows a realistic sky, very close to what you see with naked eye, binoculars or telescope. Stellarium gives astronomical data (coordinates, magnitude, distance, etc.) of most of the celestial objects visualized on the screen. You can freely download Stellarium from our site <http://vo-for-education.oats.inaf.it> or from <http://www.stellarium.org>.

6. Explore the zodiac in Stellarium

Exploring the zodiac and the motion of the Sun in Stellarium is very easy.

In order to explore the zodiac we do not need any terrestrial reference point, moreover, we want to see the Sun and the constellations also when they are below the horizon and during the day. To do this, turn off cardinal points () , atmosphere () , ground () and fog (press the F key). Then, open the search window () in the left menu, find the Sun and fix it at the centre of the screen () . Switch between equatorial and horizontal mount () and turn on the ecliptic (press the “,” key) and constellation names () and lines () .

Now we are ready to begin to follow the Sun along its apparent path in the sky. Stellarium lets us move forward and backward in time, using the arrows () at the right of the bottom menu. By clicking (more than one time) on the button with the left or right double arrow, the time is accelerated so we can have a quick view of phenomena lasting many hours, days or months. The button

“play - ▶” brings back the flow of time to its standard rate.

Accelerate the time speed and notice that the Sun moves along the constellations of the zodiac during the year. Look at the time: how many constellations does the Sun cross during its full path along the ecliptic (one year)? We are used to hear about twelve constellations of the zodiac, is it correct? Try to count and list them.

Now open the “date and time” (🕒) window, put it on the upper right corner of the screen and go forward month by month.

The Sun passes through about one constellation per month. But, if you look carefully you can notice that it stays more time in some constellations and less in others. Why? We want to go further in the zodiac exploration. Turn on the boundaries of constellations (press the B key) and follow the Sun along the ecliptic: some constellations are very large and cover a large part of the ecliptic, while others are smaller. The velocity of the Sun along the ecliptic is constant so the Sun needs more time to pass over the largest constellations.

Now we want to verify our zodiacal sign, that means look in which constellation was the Sun the day of our birth.

Open the “date and time” (🕒) window, insert your date of birth (year, month and day, the time does not matter), search for the Sun and look in which constellation you see it. Does the constellation match your sign? If not, why? Probably it does not match. The main reason is the change of constellation position due to the precession of equinoxes. Actual zodiacal signs were set up by the Chaldean civilization, 2500 years ago. Since that time the precession caused the position of stars to shift of about 30 degrees. Your sign matched the right constellation that time, not now! In the “date and time” window change your year of birth in “-500”, that means 500 BC, and look at the position of the Sun. Surely it is now more close to the right constellation. The last small shift is due to the difference between constellation and sign: as we learned before, the signs have all the same width on the ecliptic, while the constellations have not.



We thank Alessia Canelli, Karin Cescon, Dimitri Francolla and Asia Micheli, from liceo scientifico G. Galilei in Trieste, for the review of this use case done in the framework of the european project Asterics (H2020).

Our project depends on your support. If you found our material useful, we kindly ask you to acknowledge it in your publications, or to write us an email (iafrate@oats.inaf.it), or like it on our Facebook page (www.facebook.com/VOedu). Thanks!

Exercise

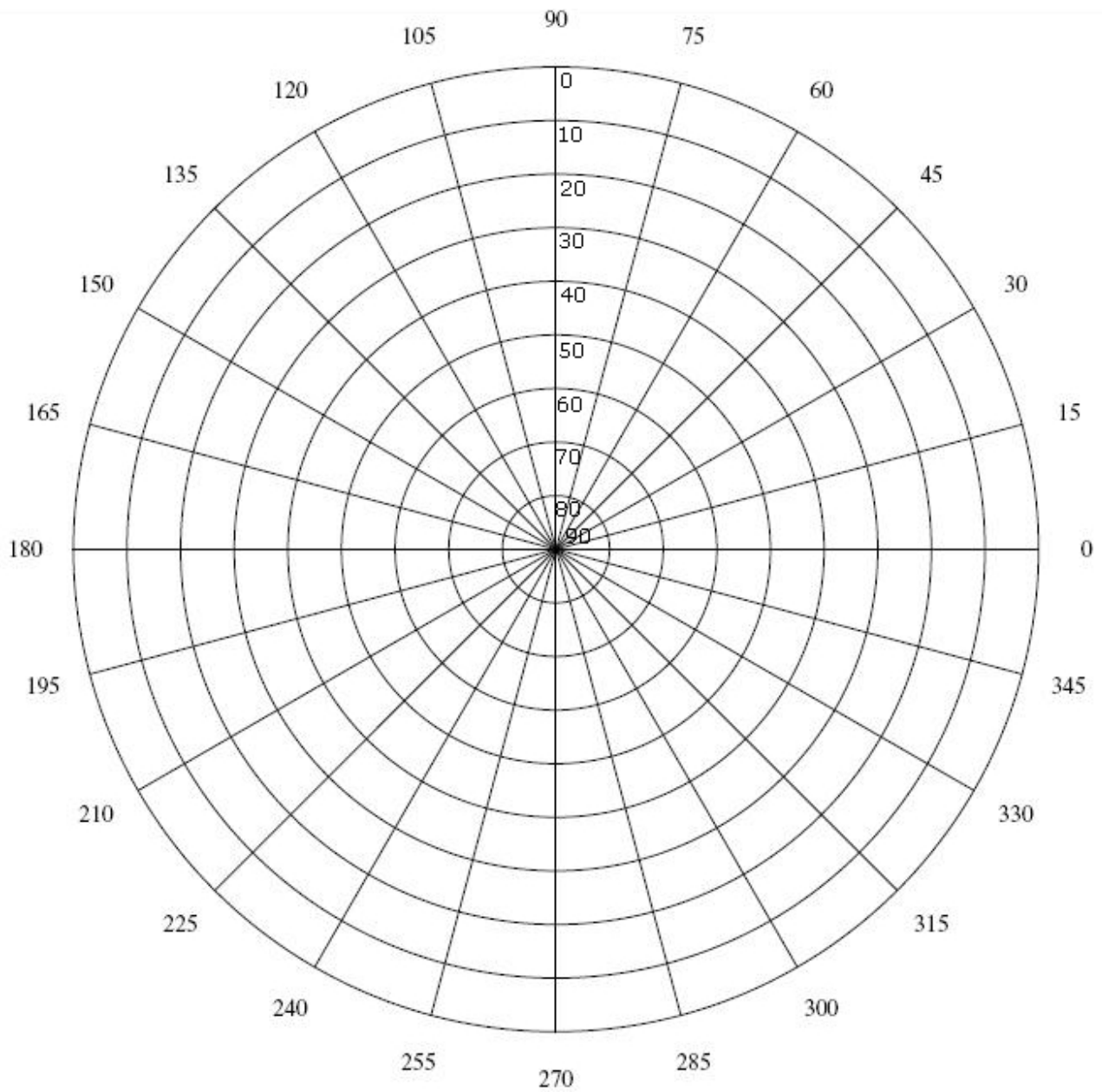
The precession of equinoxes causes star positions to change with years, with a cycle of 26000 years. Turn off ground, atmosphere and cardinal points, turn on the horizontal coordinates system. Find the Polaris and fix it at the centre of the screen.

Follow the position of the Polaris during the 26000 years cycle and fill the table with its horizontal coordinates.

Pay attention to use the same date and time for all observations (as an example the vernal equinox – March 21, at 00 UT), since the position of the stars, in the horizontal reference frame, change during the day and the year due to Earth rotation and revolution.

Plot the data on the polar graph. The external circle indicates the azimuth while the radius indicates the altitude above the horizon.

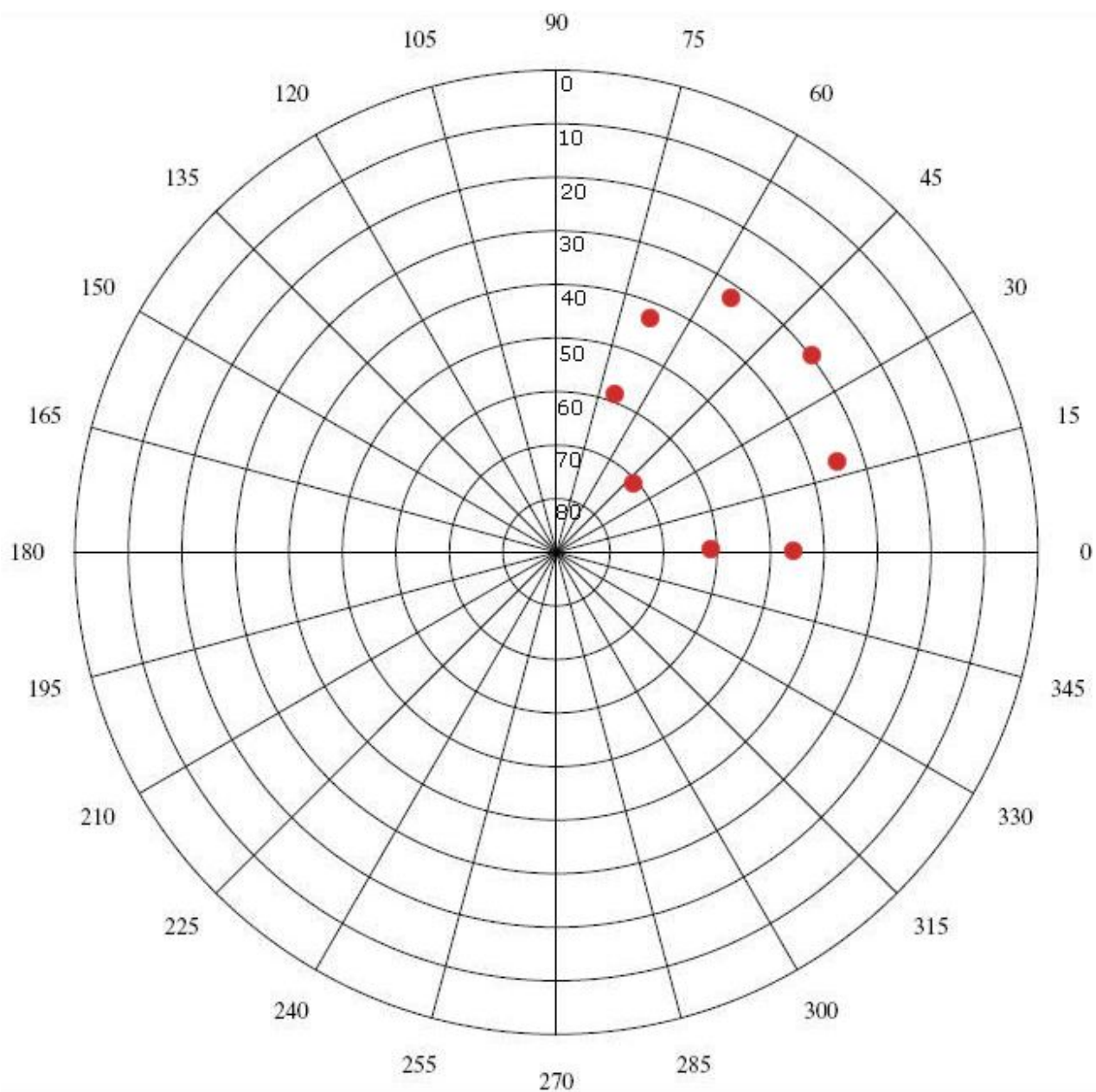
Year	Azimuth	Altitude
2000	0°	44°
5250		
8500		
11750		
15000		
18250		
21500		
24750		
28000		



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Solution

Year	Azimuth	Altitude
2000	0°	44°
5250	2°	62°
8500	43°	71°
11750	71°	58°
15000	68°	43°
18250	55°	33°
21500	37°	30°
24750	17°	35°
28000	0°	44°



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