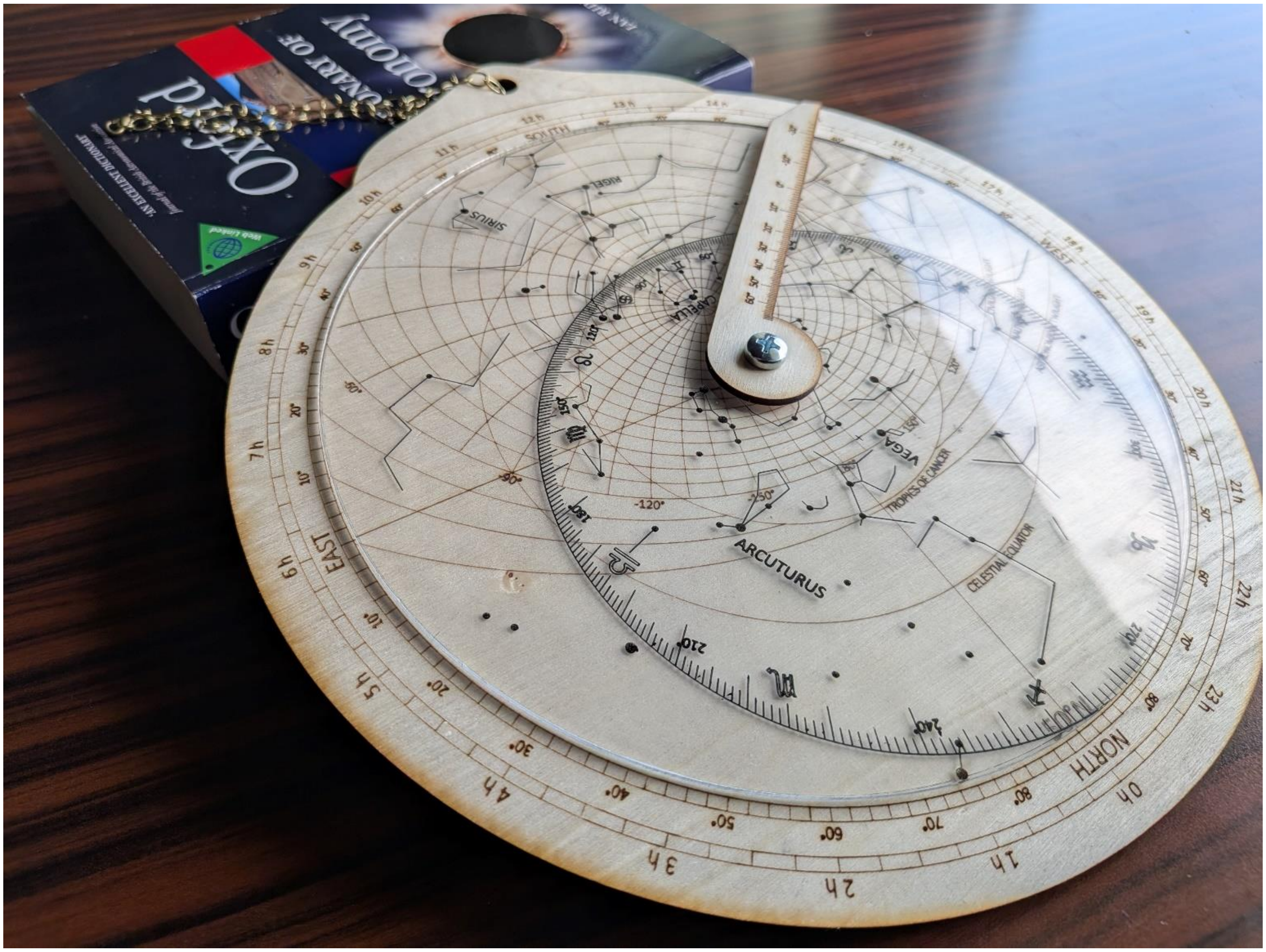


# ASTROLABE

Designed by Kristjan Salev

USER GUIDE

## CONSTRUCTION OF THE ASTROLABE

Base Plate - The sky visible at Your location

The base plate is the “foundation” of the astrolabe, representing the sky as it appears from one specific point on Earth. It is a static map over which the starry sky (on the astrolabe represented by the Rete) rotates.

1. Hour marks on the outer rim (24-hour scale)

Along the outer rim of the plate is a 24-hour scale corresponding to one full rotation of the Earth around its axis. By aligning the rotating star map (the Rete) according to the altitude of a celestial object, the rule indicates the exact local solar time on this scale. This effectively turns the astrolabe into an analogue computer that converts the positions of the stars into time.

2. Latitude and location

The base plate is constructed for a specific latitude (for example, Tallinn at 59°N). This determines how high the celestial pole stands above the horizon.

The plate is most accurate at its designated latitude but works well within ±3 to ±4 degrees (for example, a Tallinn plate functions with good accuracy throughout Estonia). If you travel too far north or south, the relative positions of the stars and the horizon change, and time calculations become less precise. The shape of the sky projection on the base plate also changes, since it is derived from a stereographic projection.

3. Celestial equator and tropic circle

At the centre of the plate is the point marking the celestial pole (the position of Polaris). Around it are several important circles:

Celestial equator — the great circle dividing the sky into northern and southern hemispheres. On the spring and autumn equinox, the Sun moves exactly along this line. The celestial equator intersects the horizon precisely at the east and west points.

Northern tropic (Tropic of Cancer) is the inner circle. It marks the Sun's path on the summer solstice. On this day, the Sun reaches its highest altitude in the northern hemisphere and stays above the horizon for the longest time.

**4.** Coordinate grid and the rule

The base plate contains a horizontal coordinate grid showing the positions of celestial objects relative to the observer's horizon.

Altitude lines — lines parallel to the horizon marking the object's height in degrees. On your plate they are drawn every 5 degrees up to the zenith (the point directly overhead).

Azimuth lines — arcs running from the zenith to the horizon, each representing a constant azimuth (angle or direction along the horizon). These are marked every 10 degrees.

The rule is marked with declination values (in degrees), indicating an object's distance from the celestial equator. Declination is 0° on the equator and increases toward the centre (the celestial pole) up to +90°. However, the primary function of the rule is to connect the Sun's position to the hour marks on the outer rim.

The plate is drawn so that its centre corresponds to the north celestial pole. Because the Earth rotates around its axis, the entire sky appears to revolve around this single point — around Polaris. For this reason, the rotating part of your astrolabe (the Rete) is also attached at this point, imitating the real rotation of the Earth in space.


**Rete — The rotating 2D model of the starry sky**

The Rete is the rotating component of the astrolabe, functioning as a real-time model of the celestial sphere. On your instrument it is made of transparent acrylic, allowing the motion of the stars to be seen clearly above the coordinate grid of the base plate.

The Rete is a two-dimensional projection of the sky. By rotating it, you simulate the Earth's rotation with complete accuracy — visually showing which stars are rising, which are at culmination, and which are setting at any given moment.

The fact that the stars appear mirrored on the Rete is a consequence of the stereographic projection. The astrolabe's map is constructed as if we were observing the celestial sphere from the outside, even though in reality we stand inside the sphere.

The Rete includes the major constellations and the brighter stars, five of which are labeled by name. Because the acrylic is transparent, the horizontal coordinate grid of the base plate remains visible beneath it, allowing you to determine the altitude and azimuth of any star in real time. All constellations drawn on the plate may be used as reference points during measurement.

The ecliptic is the offset ring on the Rete marking the Sun's annual path through the twelve zodiac signs. With it, you can determine the Sun's position relative to the starry sky on any calendar date — the essential step for determining solar time.

**Back of the astrolabe**

The back of the astrolabe contains all the scales and instruments needed to measure the altitude of the Sun or other stars and to convert those measurements into standard time. The construction is largely traditional, but your instrument includes an Equation of Time graph at the centre.

1. Altitude scale

The outermost ring on the back. It is marked from 0° to 90° altitude in each quadrant. This scale is used together with the alidade to measure the altitude of the Sun or some other star. The reading is taken directly at the edge of the alidade.

2. Zodiac ring (0–360°)

Located inside the altitude scale, it shows the twelve zodiac signs, each spanning 30° (tropical zodiac). The scale begins at 0° at the First Point of Aries which is spring equinox in northern hemisphere. It is used to determine the Sun's ecliptic longitude on a given date.

3. Calendar scale

The annual ring inside the zodiac ring. Every day of the year is marked at equal intervals. The calendar scale and the zodiac ring work together: by selecting a date, you obtain the Sun's zodiacal longitude.

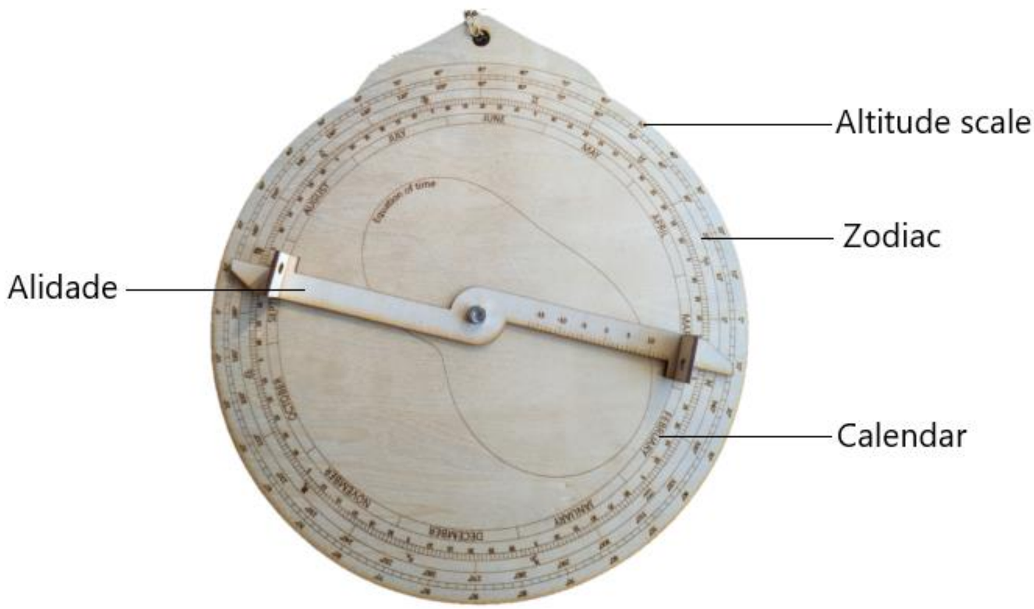
4. Equation of time graph

At the centre of the back there is no altitude grid or additional scales — only the equation of time curve. That graph helps to calculate how much solar time differs from standard time throughout the year.

5. Alidade

The alidade is the rotating sighting rule on the back of the astrolabe, used to measure the altitude of the Sun or some other star. It is also used to align the Sun's zodiac position with the date on the calendar scale.

On your astrolabe, the alidade includes a minute scale, allowing you to apply the Equation of Time correction when converting solar time to standard time.



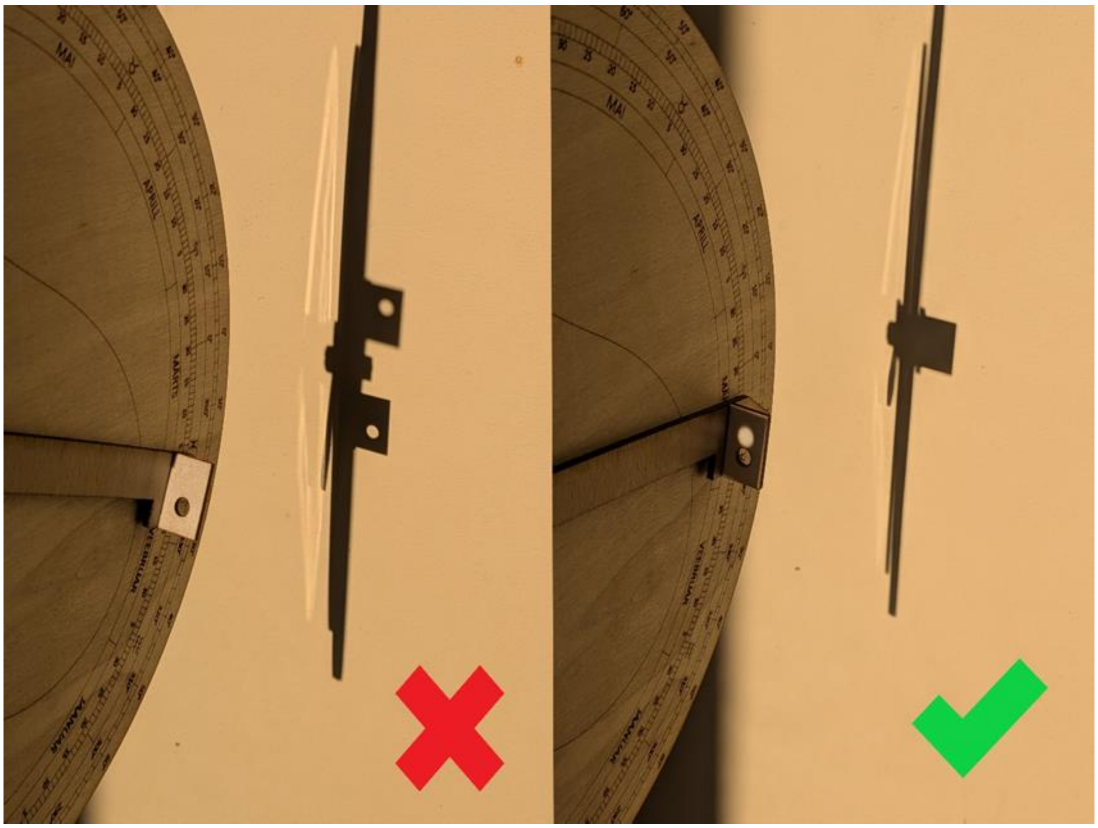

**DETERMINING TIME USING THE SUN**

**Safety warning: Never look directly at the Sun — not even through the sighting holes!**

The "ruler" on the back of the astrolabe — the alidade — is equipped with two small plates, each with a tiny aperture. Their purpose is to help you aim the instrument precisely toward the Sun without ever looking at the Sun itself. These holes are used at night when measuring the altitude of stars.

1. Measuring the Sun's altitude

Hold the astrolabe suspended freely by its chain so that the instrument hangs naturally in a vertical position. The two small plates at the end of the alidade should remain roughly aligned with each other. Aiming at the Sun is done by observing their shadows, not the Sun itself. Rotate the alidade until the shadows cast by both plates merge into a single, uniform shadow. When the shadows coincide, the plates are perfectly aligned, and the alidade is pointing directly at the Sun. You can then read the altitude angle from the outer scale at the position of the alidade.

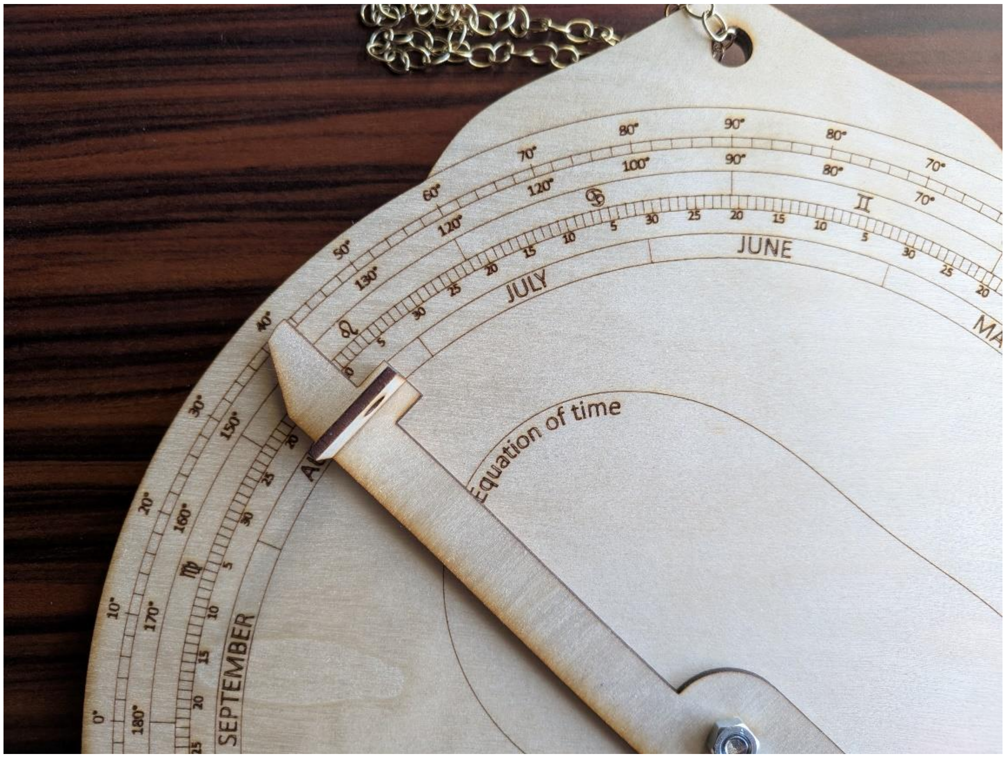


2. Determining the Sun's position on the zodiac

On the back of the astrolabe you will find the calendar scale and the 0–360° zodiac scale, which operate together. Each zodiac sign spans 30°. Using these two scales, you can determine the Sun's position - its sign and degree on any given day of the year.

To find the Sun's zodiac position, rotate the alidade to the exact calendar date on which the observation is made. You will now see on the zodiac scale which sign and degree the alidade points to.

For example, on 10 August, the Sun is at 18° Leo, meaning the Sun's ecliptic longitude on 10 August is 138°.




**3.** Positioning the Sun on the front of the astrolabe

Once the Sun's altitude and zodiac position have been determined on the back of the astrolabe, these values can be transferred to the front. The front represents the local sky using a horizontal coordinate grid, where altitude lines show how high an object is, and azimuth lines show in which direction it lies.

At this stage, you place the Sun on the model exactly where it is in the real sky.

To determine the Sun's position on the front:

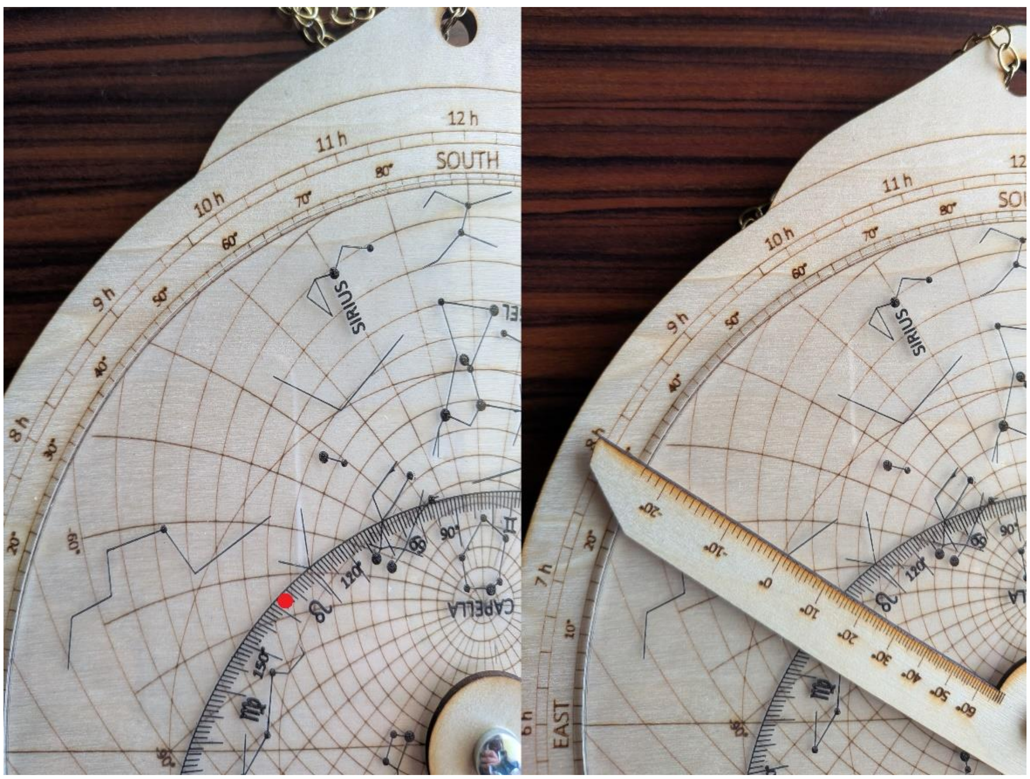
Locate on the rete's ecliptic ring the exact degree you read from the back. This marks where the Sun lies on that date.

Example: 10 August → 18° Leo → 138° on the rete.

Find on the base plate the altitude line corresponding to your measured solar altitude.

Example: measured altitude 32° in the morning → the Sun must lie between the 30° and 35° altitude lines. Rotate the rete until the Sun’s position falls between those altitude lines.

It is also essential to check the direction. The Sun must appear on the correct side of the plate: in the east during the morning and in the west during the afternoon.




**4.** Reading local solar time

When the Sun has been placed correctly on the front of the astrolabe — on the proper altitude line, in the correct direction, and at the correct position on the ecliptic — you can read the local solar time. This is the time that a sundial will show.

Along the outer rim of the astrolabe is a full 24-hour time scale with 15-minute divisions, allowing the time to be read with good precision. To determine the time, the rule must pass exactly through the point on the ecliptic ring where the Sun is located. In our example, the time indicated is about 08:00 in the morning.

5. Converting local solar time to standard time

The local solar time read from the astrolabe represents the time that a sundial would show. The time indicated by ordinary clocks (standard time) may differ from this for three reasons.

The first factor is geographical longitude, often called the meridian correction. True solar time depends on your actual longitude, whereas standard time is based on the central meridian of your time zone. There are exactly 24 central meridians because the Earth is divided into 24 time zones, each spanning 15° of longitude. This division follows directly from the fact that the Earth rotates 360° in one day, which corresponds to 15° per hour.

For example, the central meridian of Germany's time zone (UTC+1) is 15° east longitude. Berlin lies approximately 13.5° east, which is 1.5° west of the central meridian. Each degree of longitude corresponds to 4 minutes of time, so in Berlin about +6 minutes must be added to local solar time to obtain mean solar time. If the location were east of the central meridian, the solar time would be ahead, and the corresponding minutes would need to be subtracted instead.

The second factor is the equation of time. The Sun's apparent motion in the sky is not perfectly uniform because of the Earth's orbital position. To reconcile this with mean solar time, a correction must be applied. The difference can be as large as ±16 minutes depending on the date. This is why the back of the astrolabe includes the equation of time curve: it shows how much must be added to or subtracted from local solar time on any given day to obtain mean solar time.

The third factor is the use of daylight-saving time. During the summer months (from March to October), one hour is added to standard time. Therefore, when daylight saving time is in effect, you must always add +1 hour when converting local solar time. No such adjustment is needed when standard time is in effect.

All the information required to determine standard time is present on the back of your astrolabe: the date scale, the equation of time curve, and the alidade, which is used to align the date with the corresponding correction.

Example: Converting local solar time to standard time

Date: 10 August

Location: Berlin

Local solar time read from the astrolabe: 08:00

The first step is the meridian correction. The central meridian of Germany's time zone is 15°E, while Berlin lies at approximately 13.5°E. The difference is 1.5° to the west, which corresponds to a time correction of:

$1.5° \times 4$ minutes = +6 minutes

08:00 becomes 08:06.

Next comes the equation of time correction. The equation of time curve on your astrolabe shows that on 10 August the correction is +6 minutes. This is added to the previous result:

08:06 becomes 08:12.

Finally, daylight saving time must be applied. During summertime, one hour is added:

08:12 becomes 09:12.

This is the result, corresponding to the conventional clock time.

**DETERMINING TIME AT NIGHT**

It is also possible to determine solar time during the night. Since the date is known, the Sun's zodiac position is known as well. The altitude of a star is used only to rotate the rete into the correct orientation so that the entire sky model matches the real night sky. Once the rete has been set correctly using a star, the Sun's position on the ecliptic can be read from the same time scale that you use during the day.

1. Measuring a star's altitude with the alidade

Hold the astrolabe by its chain so that it hangs freely and remains vertical.

Use bright stars such as Vega, Sirius, Arcturus, Capella, or Rigel, as well as any other prominent stars that form constellations and are marked on the rete.

Rotate the alidade toward the chosen star. Looking through the sighting holes — the star's point of light must appear centered in both apertures. When the star remains centered in both openings, the alignment is correct.

2. Locating the star on the rete

Find on the rete the star whose altitude you have just measured.

The fixed position of this star serves as a reference point for rotating the entire Rete into the correct orientation.

3. Setting the rete to the measured altitude of the star

Located on the base plate, the altitude line corresponding to the measured altitude.

Rotate the rete until the chosen star lies exactly on that altitude line.

Check the direction as well: the star must appear on the plate at the same azimuth in which it appears in the sky.

Once this is done, the entire rete is correctly oriented — all stars, and the Sun (even though it is below the horizon), are now in their correct positions on the model.

4. Determining the Sun's position

The Sun's position on the ecliptic is determined in the same way as during the day: on the back of the astrolabe, rotate the alidade to the date, read the zodiac degree, and locate the same position on the ecliptic ring of the rete.

5. Reading local solar time

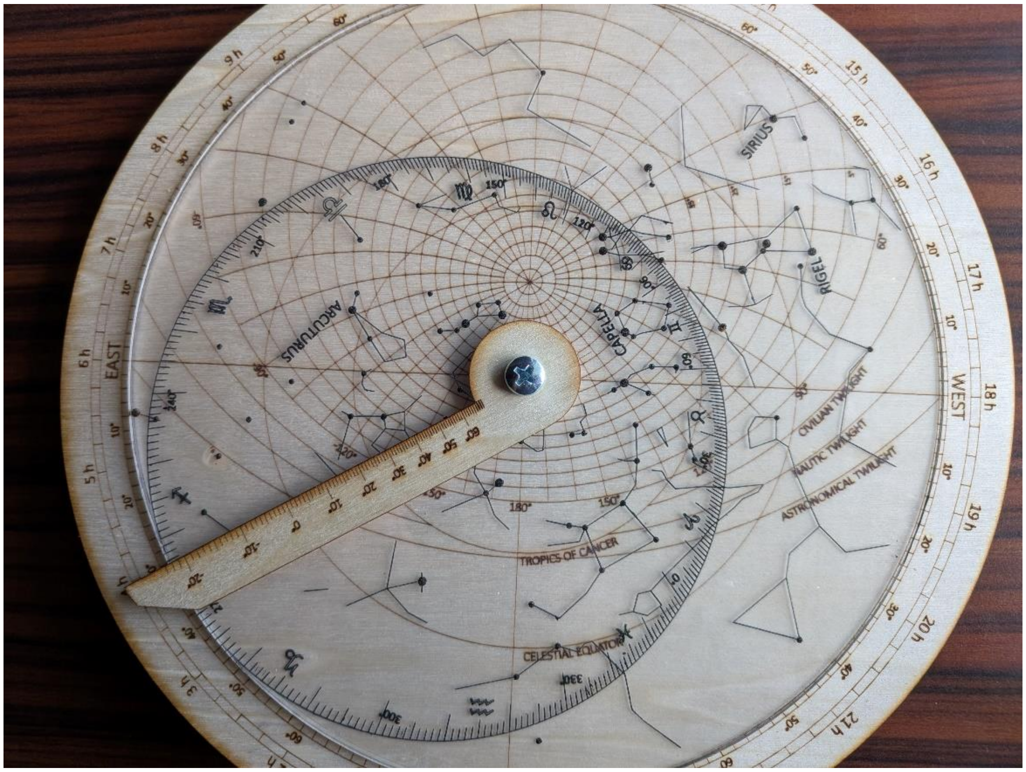
The time is read in the same way as during the day - from the 24-hour scale on the outer rim. Since the rete has been oriented correctly using a star, the scale now shows the correct local solar time.

Conversion to standard time uses the same corrections as during the day:

meridian correction + equation of time + daylight saving adjustment.

Example:

Suppose that on 15 December you measure the bright star Rigel in the constellation Orion to be about 10 degrees above the horizon in the western sky. As shown in the illustration, the Sun is then below the horizon, and the local solar time is approximately 04:00




Converting to standard time:

From the equation of time, we see that on this date the correction is –5 minutes.

Thus, 04:00 becomes 03:55.

The second correction again comes from the time-zone central meridian.

For Berlin this is +6 minutes:

03:55 becomes about 04:01.

Since wintertime is in effect, no additional hour needs to be added.

The final standard time is therefore 04:01.

## DETERMINING THE TIME OF SUNRISE, SUNSET, AND DAY LENGTH

With the astrolabe you can determine not only the time of day but also the moments of sunrise and sunset. This is one of the instrument's traditional core functions: finding the exact moment when the Sun touches the horizon or rises above it.

Since the Sun's zodiac position is known from the date, it can be placed in the correct location on the Rete, after which the entire sky model can be rotated until the Sun reaches the horizon.

After determining the Sun's ecliptic position, rotate the Rete until the Sun touches the horizon (the 0° altitude line). If the Sun lies on the eastern side, the moment is sunrise; if on the western side, it is sunset. Align the rule with the Sun's position on the ecliptic and read the sunrise or sunset time from the outer rim of the disk.

The length of the day is simply the interval between sunrise and sunset, and the length of the night is the remainder of the 24-hour cycle. Once the moments of sunrise and sunset have been determined with the astrolabe, the durations of day and night can be calculated immediately without any additional steps.

## TWILIGHT ZONES

On the astrolabe's base plate, below the horizon, are three separate altitude lines corresponding to the Sun's positions at −6°, −12°, and −18°. These mark the three stages of twilight that occur before sunrise and after sunset. By placing the Sun on any of these lines on the model, you can determine the beginning or end of the corresponding twilight phase.

Twilight is traditionally divided into three types.

Civilian twilight (Sun from 0° to −6° below the horizon)

This is the brightest twilight. There is enough light to move around and read without artificial illumination. In everyday life it is often considered the practical "beginning and end of the day."

Nautical twilight (Sun from −6° to −12° below the horizon)

The horizon is still clearly visible, and the brighter stars are also visible. Historically, sailors used this period for navigation, as both the stars and the horizon could be seen simultaneously.

Astronomical twilight (Sun from −12° to −18° below the horizon)

This is the darkest twilight. When the Sun is more than 18° below the horizon, the sky becomes fully dark and all stars are visible — ideal conditions for astronomical observation.