The Planisphere

A Cardboard Computer!

the Visible Sky

I. **Stars and Celestial Sphere**
Constellations & Coordinates

II. **Sun**
Time, Seasons, Precession

III. Moon
Phase, Orbit, etc.

IV. Eclipses
Solar & Lunar

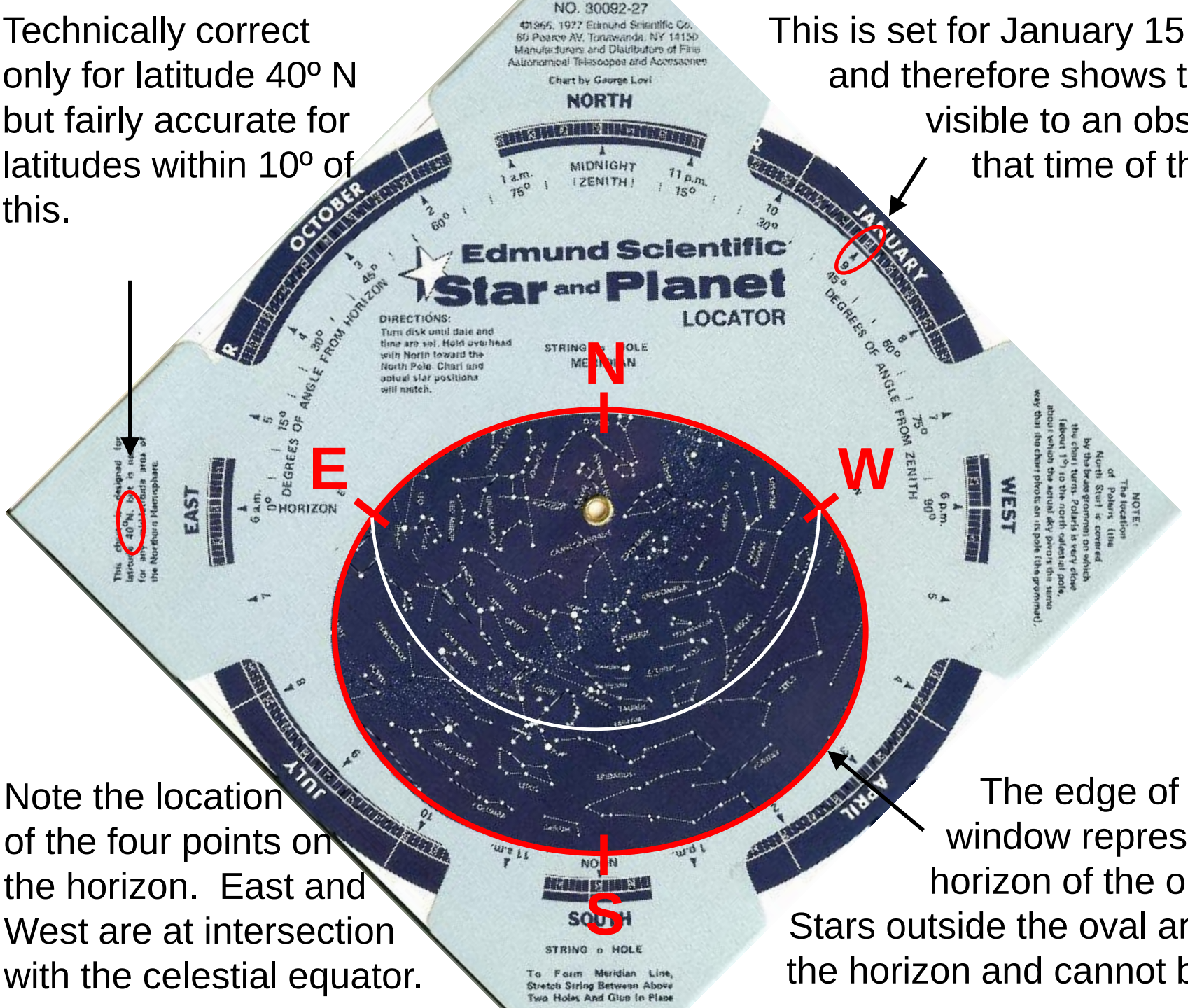
The student will be able to:		HW:
1	Explain and utilize constellations and asterisms as means of mapping and organizing the stars.	1 – 4
2	Explain and utilize the concept of the celestial sphere as a means of understanding the appearance of the universe as seen from Earth.	
3	Explain the significance of the pole star, Polaris, and its connection with the apparent motion of the celestial sphere.	
4	Explain, define, and utilize the celestial equatorial coordinate system of right ascension and declination, celestial equator and celestial poles.	
5	Describe changes in position and appearance of the stars through time and explain in terms of the actual motion and position of the Earth.	5
6	Define, apply, and relate to astronomical events or cycles the following time concepts: sidereal and solar day, sidereal and tropical year, mean solar time, standard time, daylight savings time, and universal time.	6
7	Use a planisphere to locate celestial objects for a particular date and time and/or determine the date and time of certain celestial events.	7 – 8
8	Describe changes in position and appearance of the Sun through time and explain in terms of the actual motion and position of the Earth.	9
9	State the constellations of the zodiac in order and explain the relation between the zodiac and the Sun.	10 – 14
10	Explain, define, and utilize the concept of the ecliptic and the ecliptic plane.	
11	Illustrate and describe the connection between the seasons and the motion and orientation of the Earth in its orbit.	15
12	Explain the cause and effect of Earth's precession and state and apply the period of this cycle to solve problems.	16
13	Describe changes in the appearance of the Moon over the course of one day and night, from one night to the next, from one week to the next, from one month to the next, and from year to year.	17 – 20
14	Explain the apparent motion and changing appearance of the Moon in terms of the actual motions of the Earth and Moon relative to the Sun.	
15	Explain and illustrate how the motion and position of the Moon relative to the Earth and the Sun result in the phases: new Moon, waxing crescent, first quarter, waxing gibbous, full Moon, waning gibbous, third quarter, and waning crescent.	
16	Define, apply, and relate to astronomical events or cycles the following concepts: sidereal month, synodic month, lunar sidereal and solar days.	21 – 22
17	Explain and illustrate how the motions and positions of the Earth, the Sun, and the Moon result in lunar and solar eclipses – partial, total, and annular.	23
18	Explain and illustrate the concepts of umbra and penumbra in relation to eclipses.	24

Planisphere

- A planisphere is a “star wheel” that displays the stars visible to an observer at a certain latitude at a particular time and date.
- To use the planisphere, simply turn the wheel until the time of day is aligned with the date in question. Once this is done the stars that are visible in the window are visible in your sky! (with some exceptions)

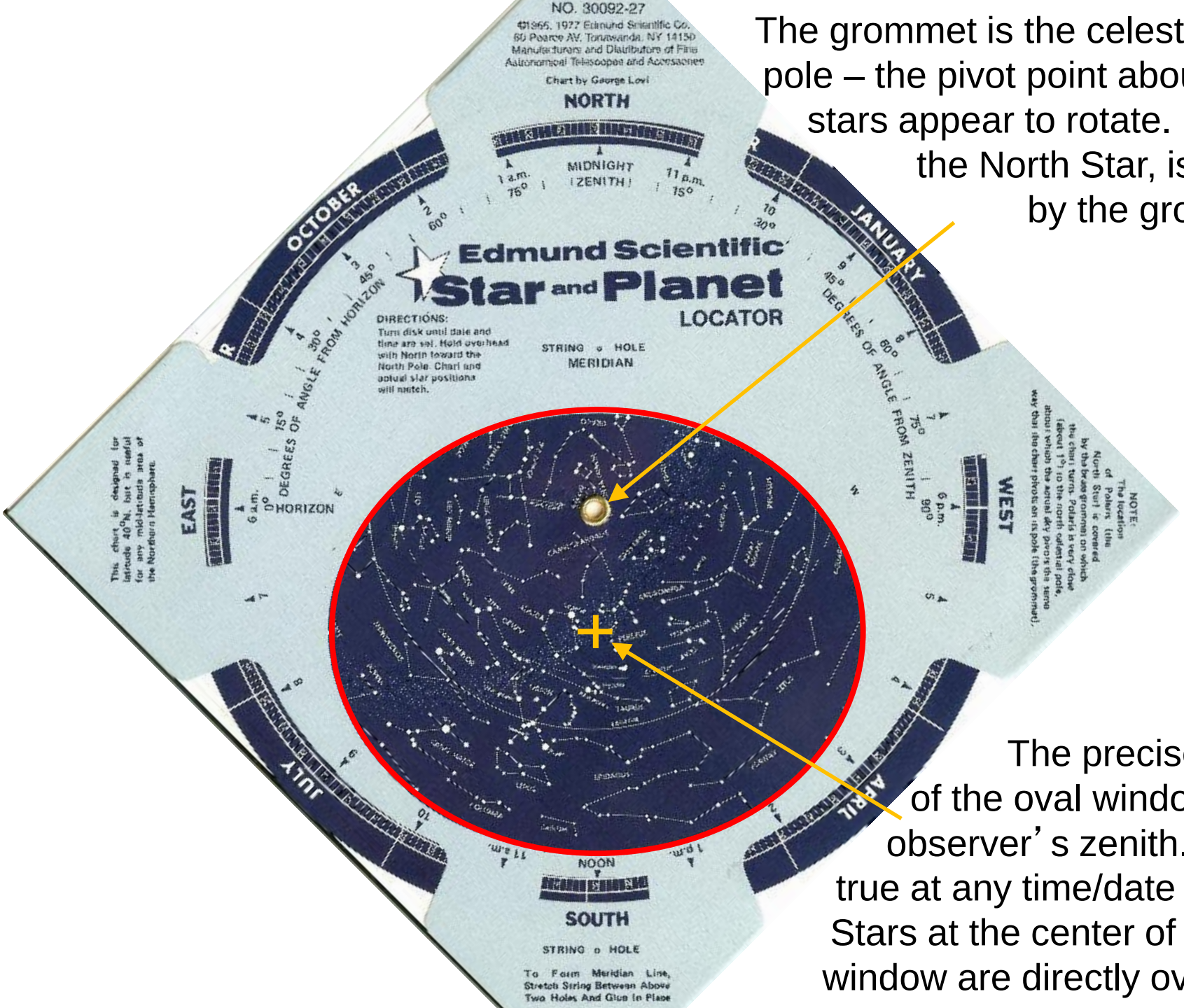
Technically correct only for latitude 40º N but fairly accurate for latitudes within 10º of this.

This is set for January 15 at 9 pm and therefore shows the stars visible to an observer at that time of the night.



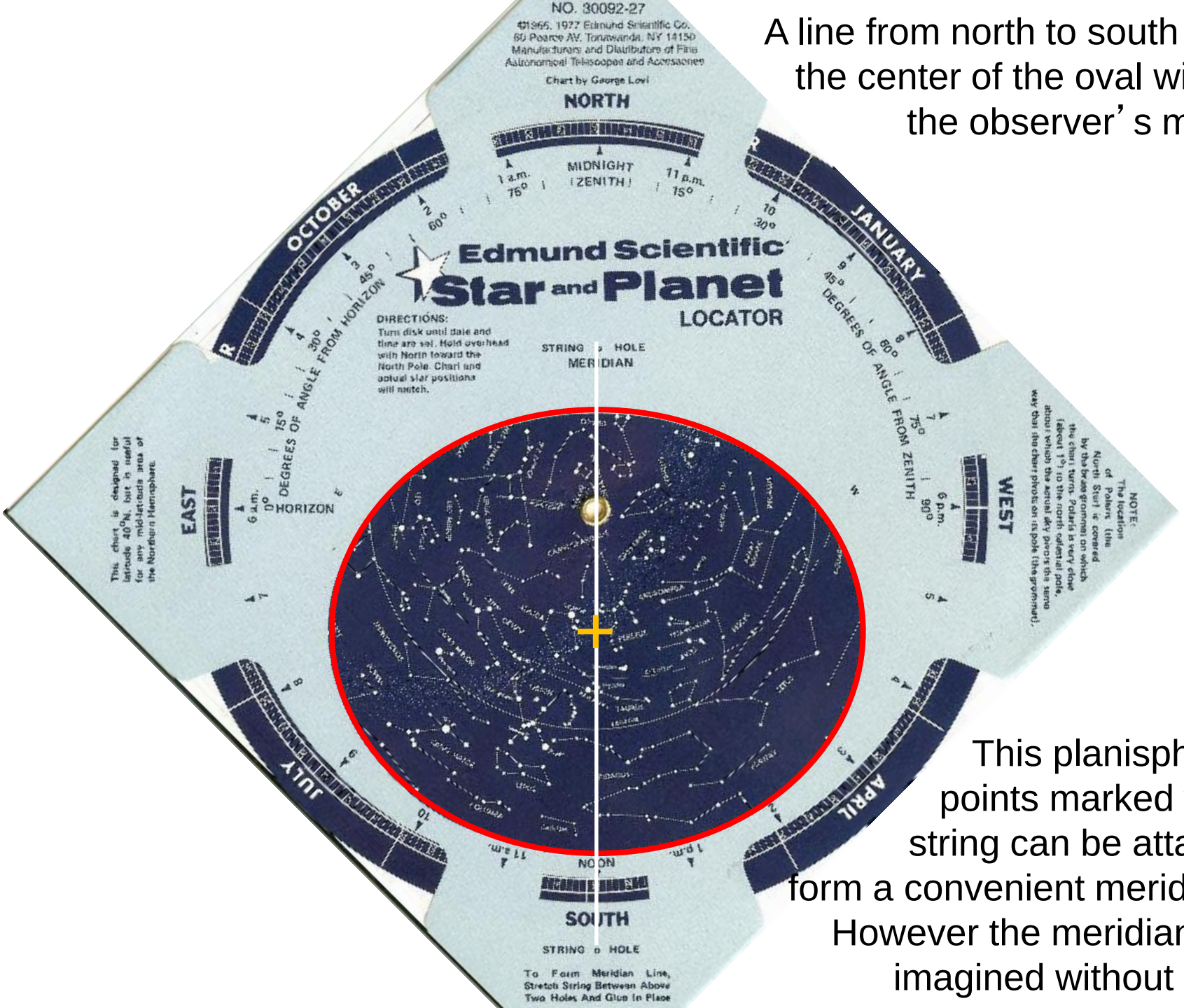
Note the location of the four points on the horizon. East and West are at intersection with the celestial equator.

The edge of the oval window represents the horizon of the observer. Stars outside the oval are below the horizon and cannot be seen.



The grommet is the celestial north pole – the pivot point about which stars appear to rotate. Polaris, the North Star, is hidden by the grommet !

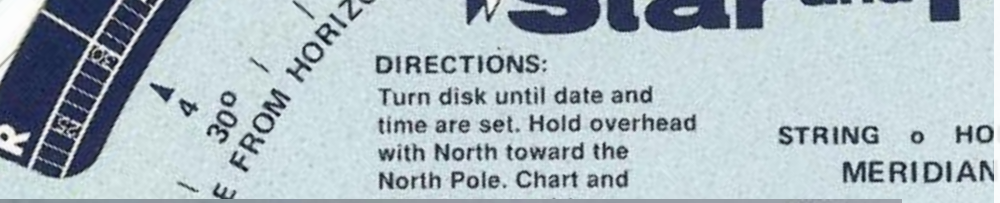
The precise center of the oval window is the observer's zenith. This is true at any time/date chosen. Stars at the center of the oval window are directly overhead.

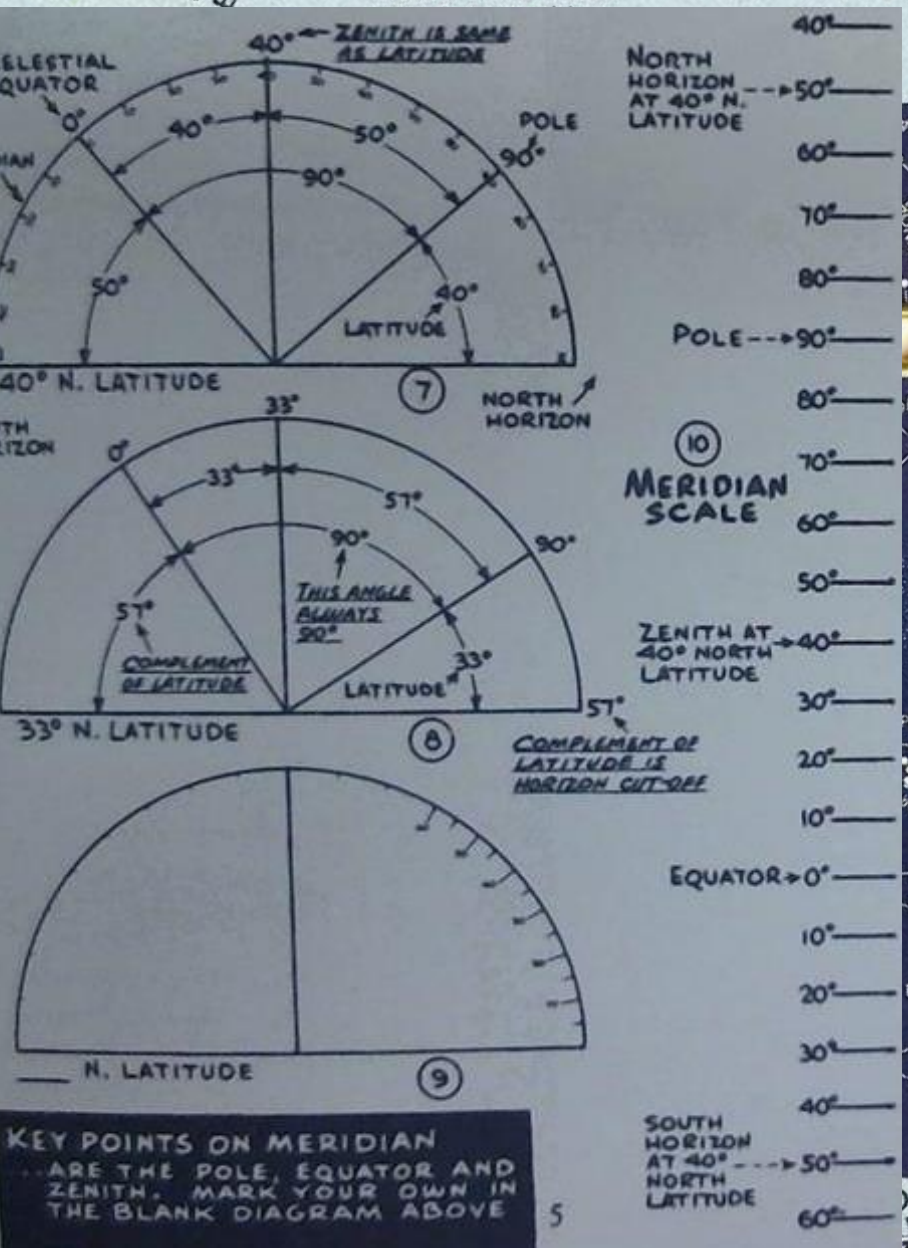


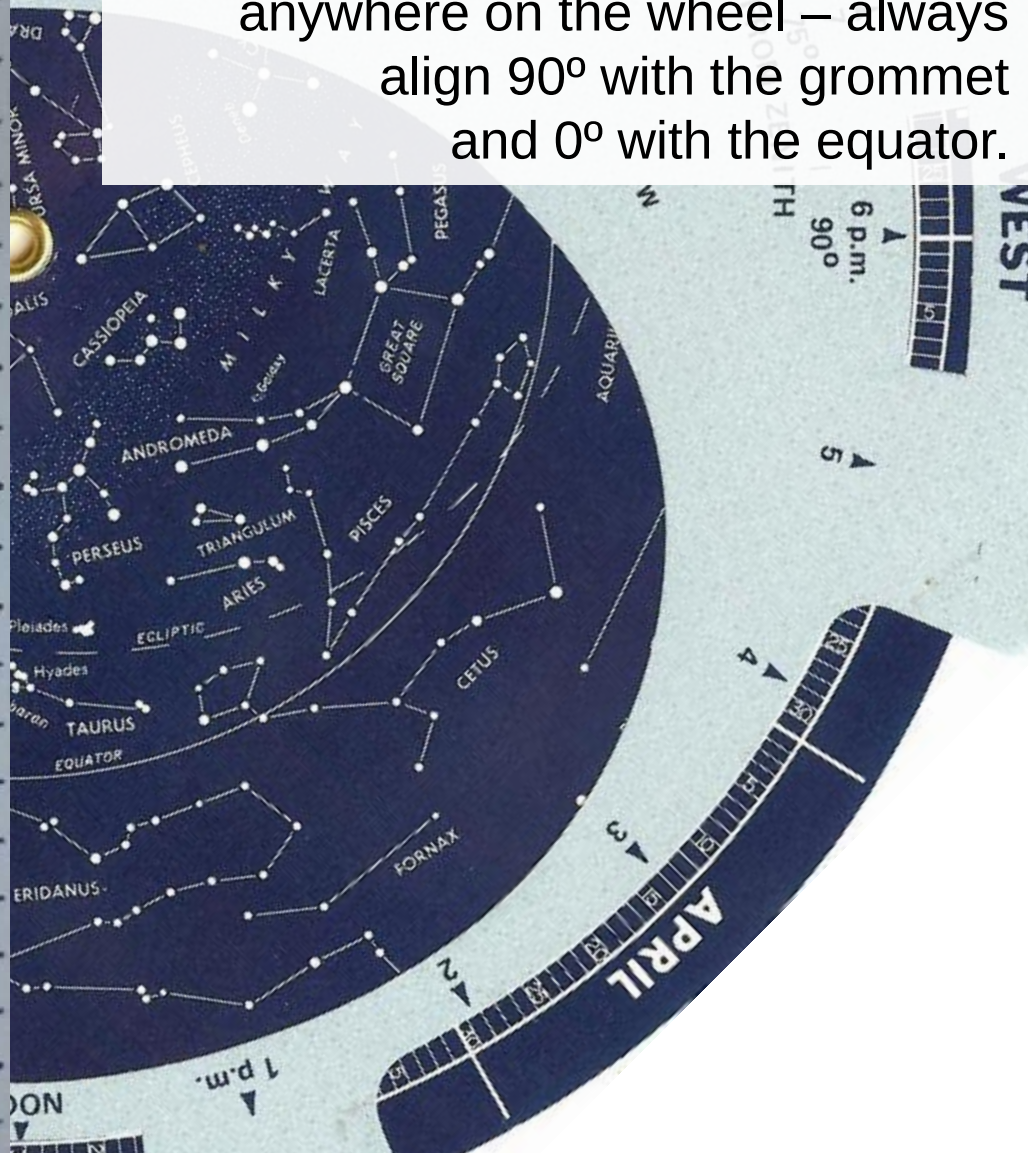
A line from north to south through the center of the oval window is the observer's meridian.

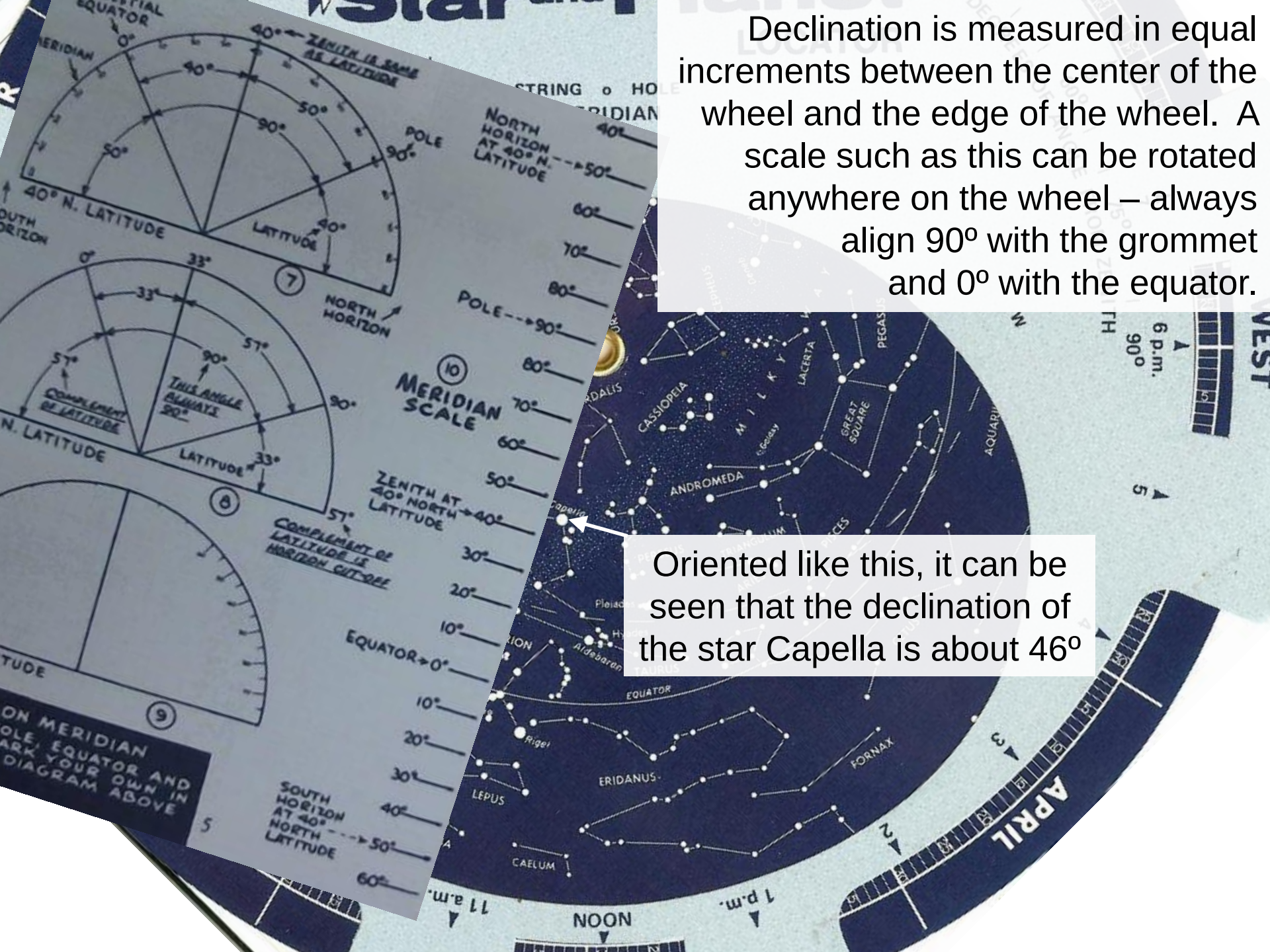
This planisphere has points marked where a string can be attached to form a convenient meridian line. However the meridian can be imagined without a string.

Declination is measured in equal increments between the center of the wheel and the edge of the wheel. A scale such as this can be rotated anywhere on the wheel – always align 90º with the grommet and 0º with the equator.








Declination is measured in equal increments between the center of the wheel and the edge of the wheel. A scale such as this can be rotated anywhere on the wheel – always align 90º with the grommet and 0º with the equator.
Oriented like this, it can be seen that the declination of the star Capella is about 46º
MERIDIAN SCALE
NORTH HORIZON AT 40° N. LATITUDE
SOUTH HORIZON AT 40° NORTH LATITUDE
ZENITH AT 40° NORTH LATITUDE
POLE
EQUATOR
NOON
APRIL
CASSIOPEIA
ANDROMEDA
GREAT SQUARE
PEGASUS
LACERTA
MILKY WAY
TAURUS
ERIDANUS
FORNAX
LEPUS
CAELUM
Capella
Rigel
Aldebaran
Pleiades

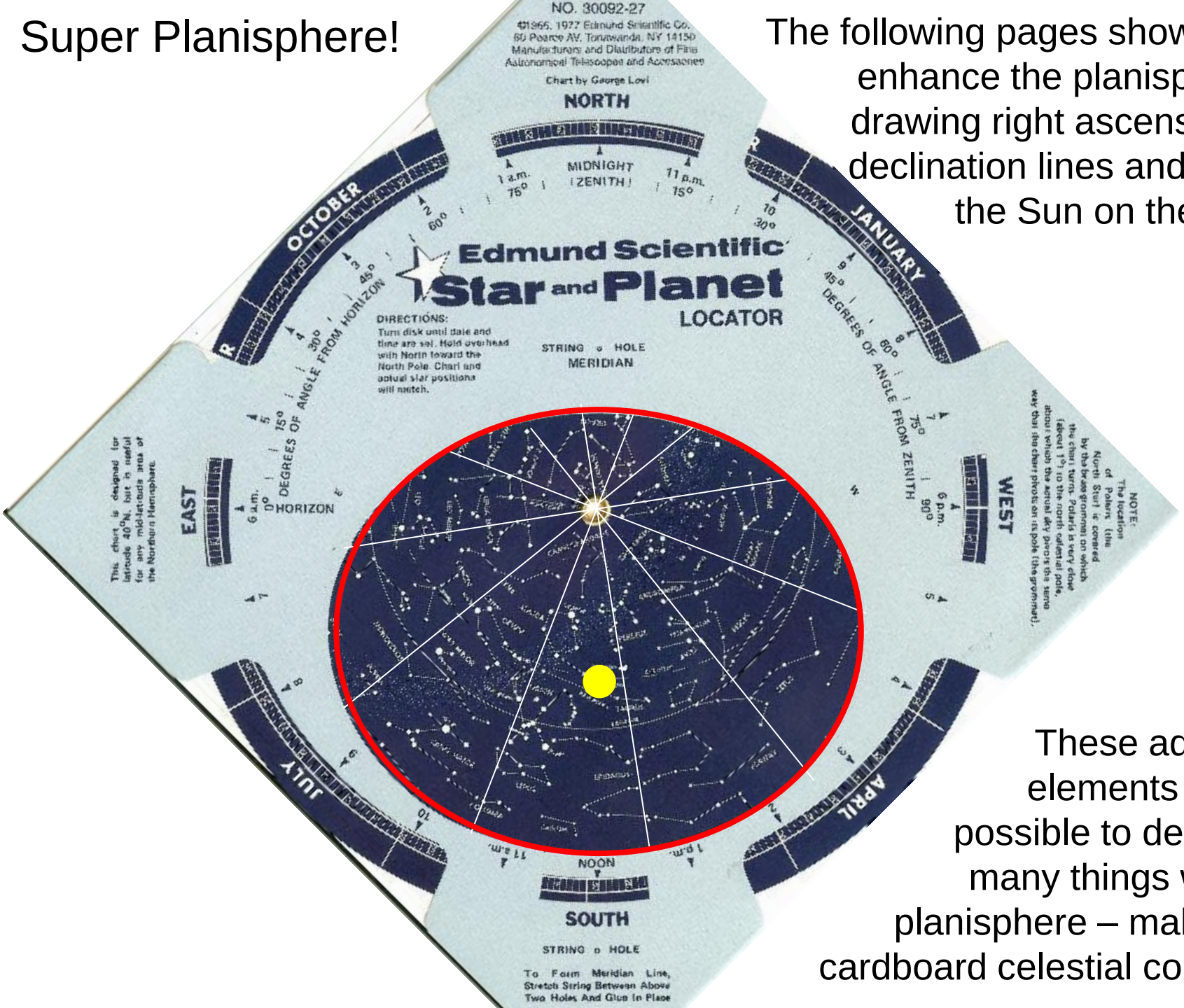
Practice using the planisphere…

1. What constellations have stars that are found in the circumpolar region? These stars do not go below the horizon at any date or time as the wheel spins.
2. For 10 p.m. July 10 determine the constellation nearest: (a) zenith, (b) south horizon, (c) west horizon.
3. Repeat for midnight July 10.
4. At what times does the star Rigel in Orion rise and set on Oct. 31?
5. On what date does Arcturus in Bootes cross the observer's meridian at midnight?
6. What is the sidereal time of the previous event? On what date does sidereal time most closely match mean solar time?

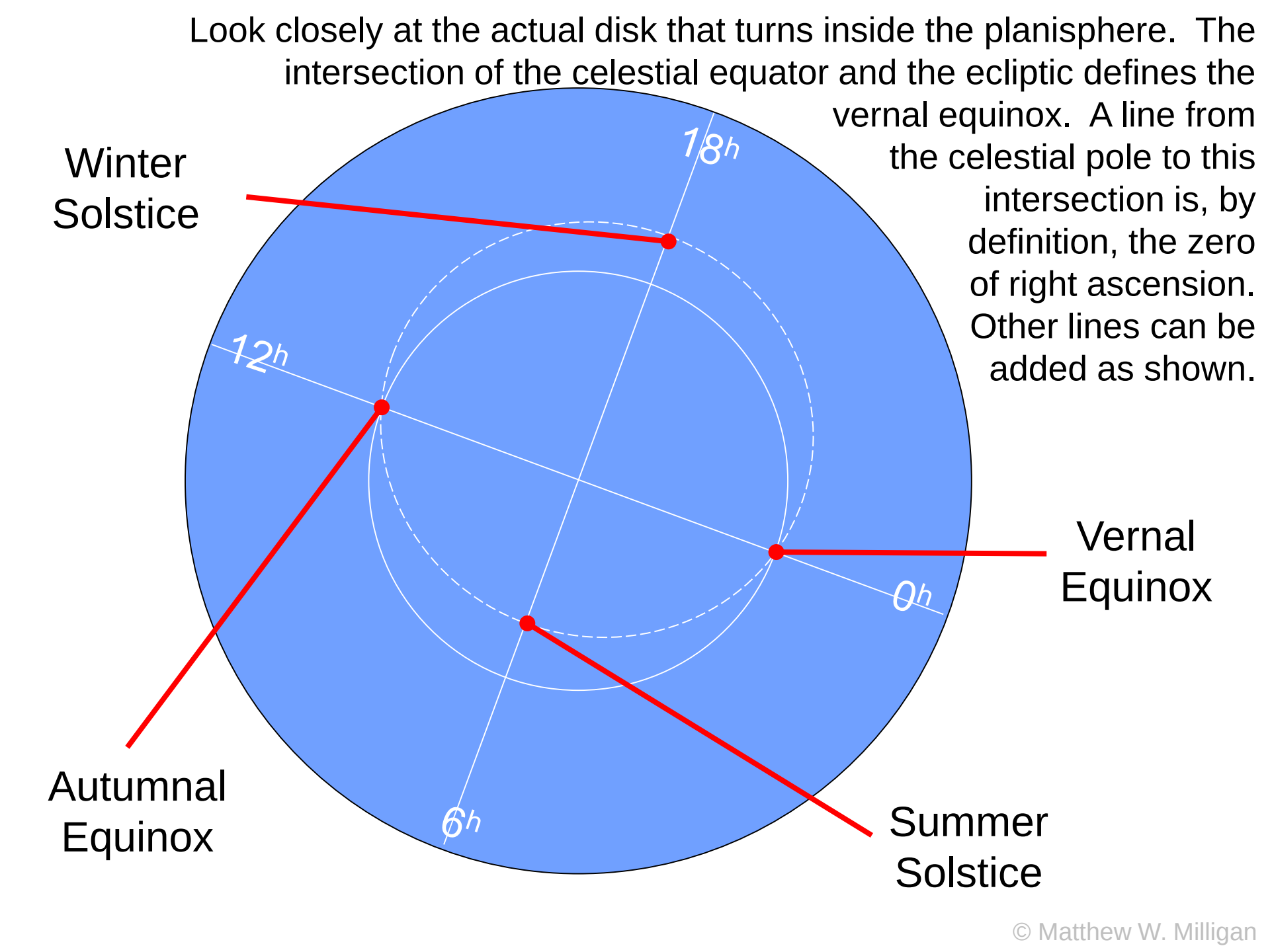
1. Ursa Major, Ursa Minor, Draco, Camelopardalis, Cepheus, Cassiopeia 2. a. Hercules, b. Scorpius, c. Crater or Virgo 3. a. Lyra, b. Corona Australis, c. Virgo 4. 9:10 pm, 8:10 am 5. April 29 6. 14^h15^m is the right ascension of Arcturus – whenever it crosses the meridian the sidereal time is 14:15. Sidereal time closely matches mean solar time only on September 22 or 23.

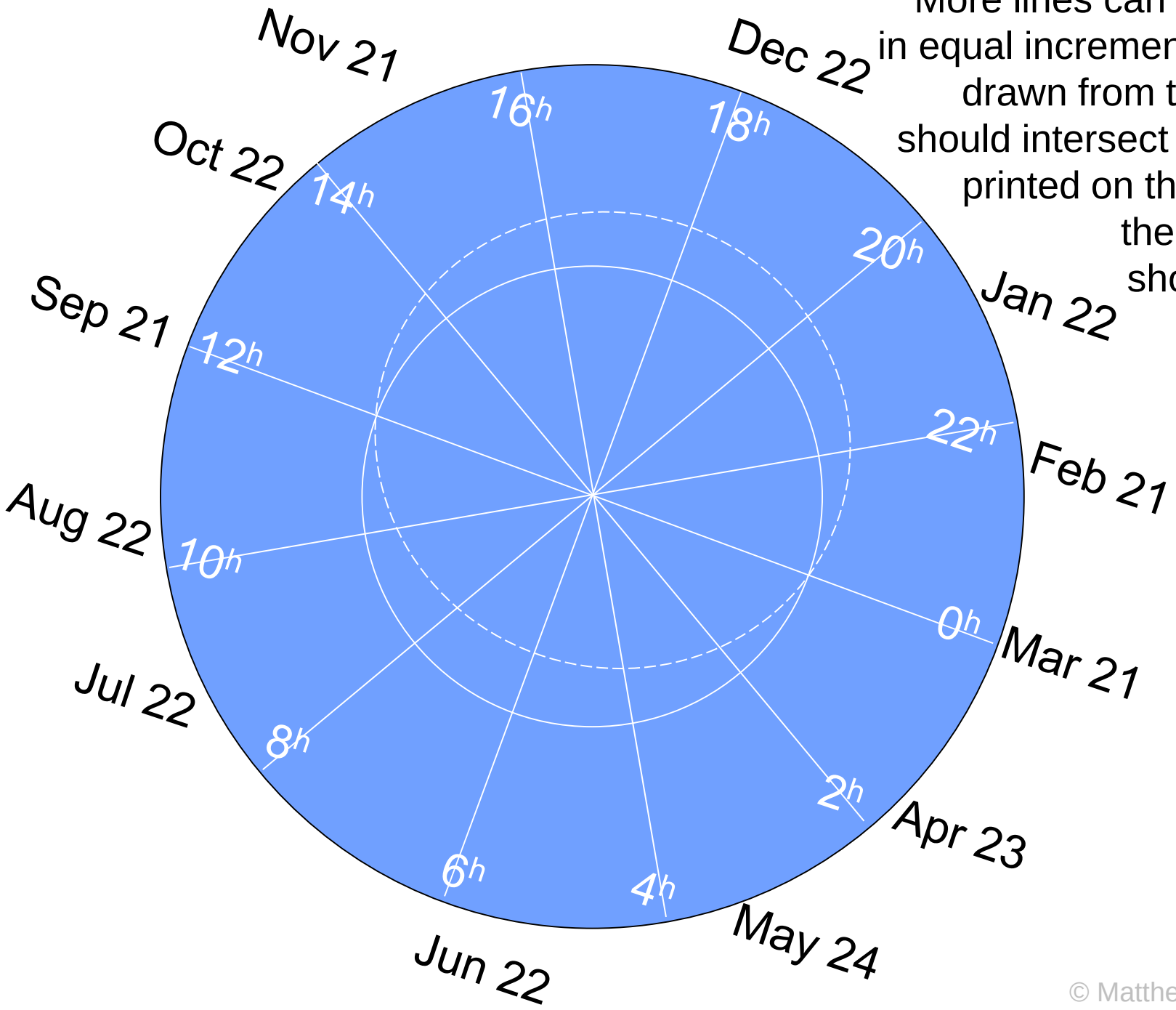
Super Planisphere!

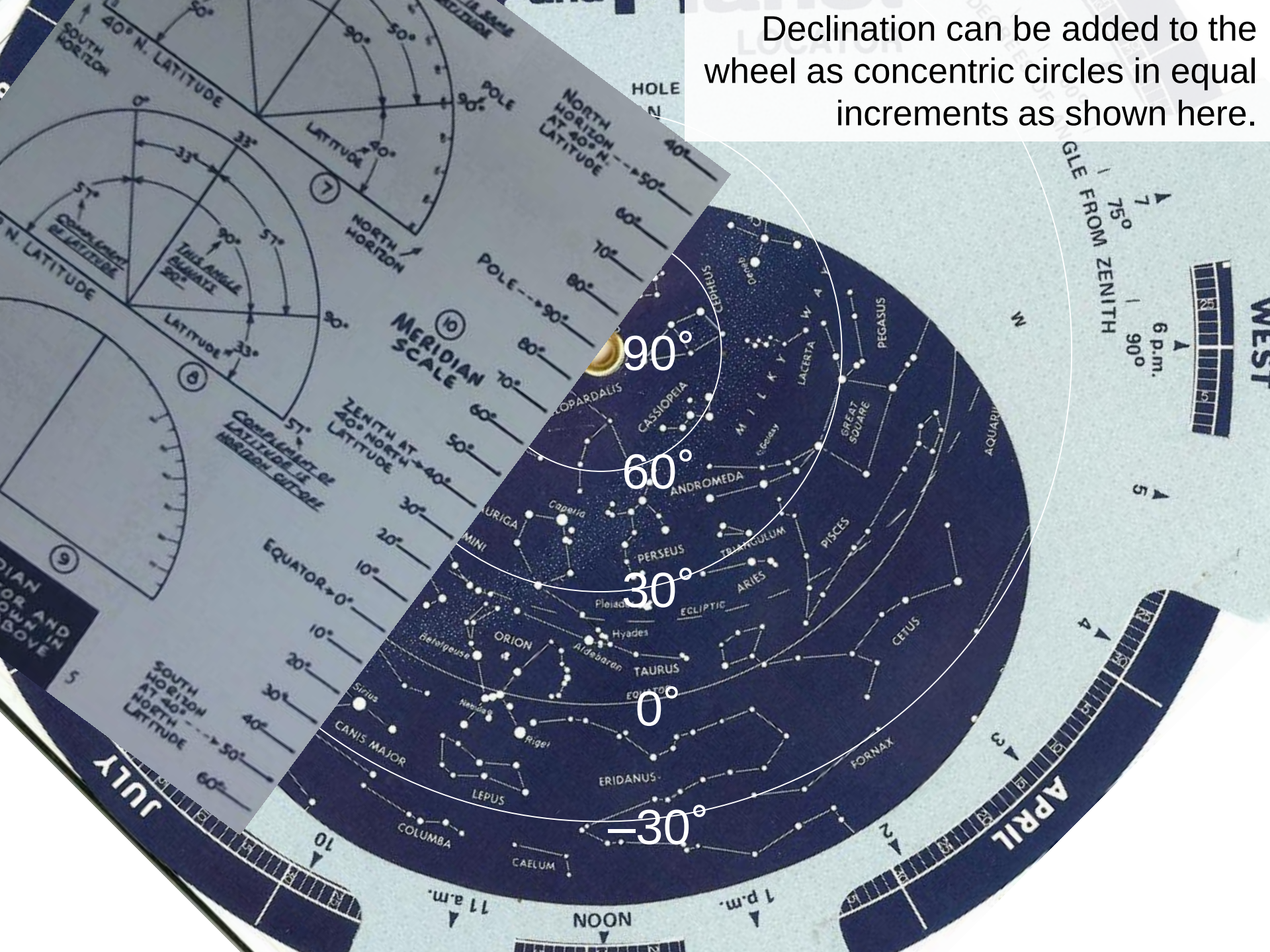
The following pages show how to enhance the planisphere by drawing right ascension and declination lines and placing the Sun on the wheel.



These additional elements make it possible to determine many things with the planisphere – making it a cardboard celestial computer!

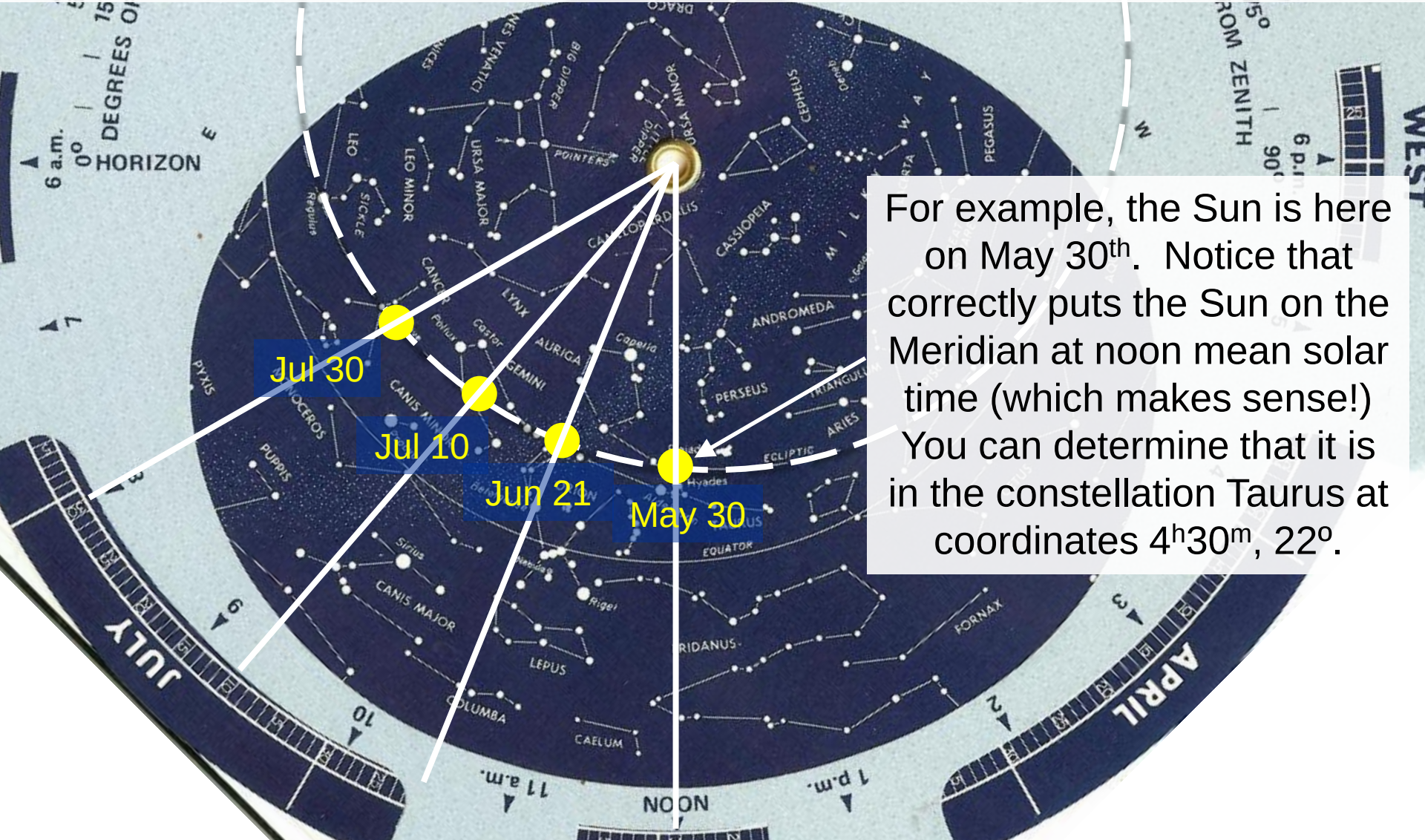





Declination can be added to the wheel as concentric circles in equal increments as shown here.
90°
60°
30°
0°
−30°
MERIDIAN SCALE
EQUATOR
NORTH HORIZON
SOUTH HORIZON
POLE
ZENITH AT 40° NORTH LATITUDE
NOON
11 a.m.
1 p.m.
6 p.m.
WEST
JULY
APRIL
ANGLE FROM ZENITH
ORION
TAURUS
ARIES
PISCES
PERSEUS
ANDROMEDA
CASSIOPEIA
CEPHEUS
PEGASUS
GREAT SQUARE
CETUS
ERIDANUS
FORNAX
CANIS MAJOR
LEPUS
COLUMBA
CAELUM
AURIGA
LACERTA
MILKY WAY
Capella
Sirius
Rigel
Betelgeuse
Aldebaran
Hyades
Pleiades
Nebula
ECLIPTIC

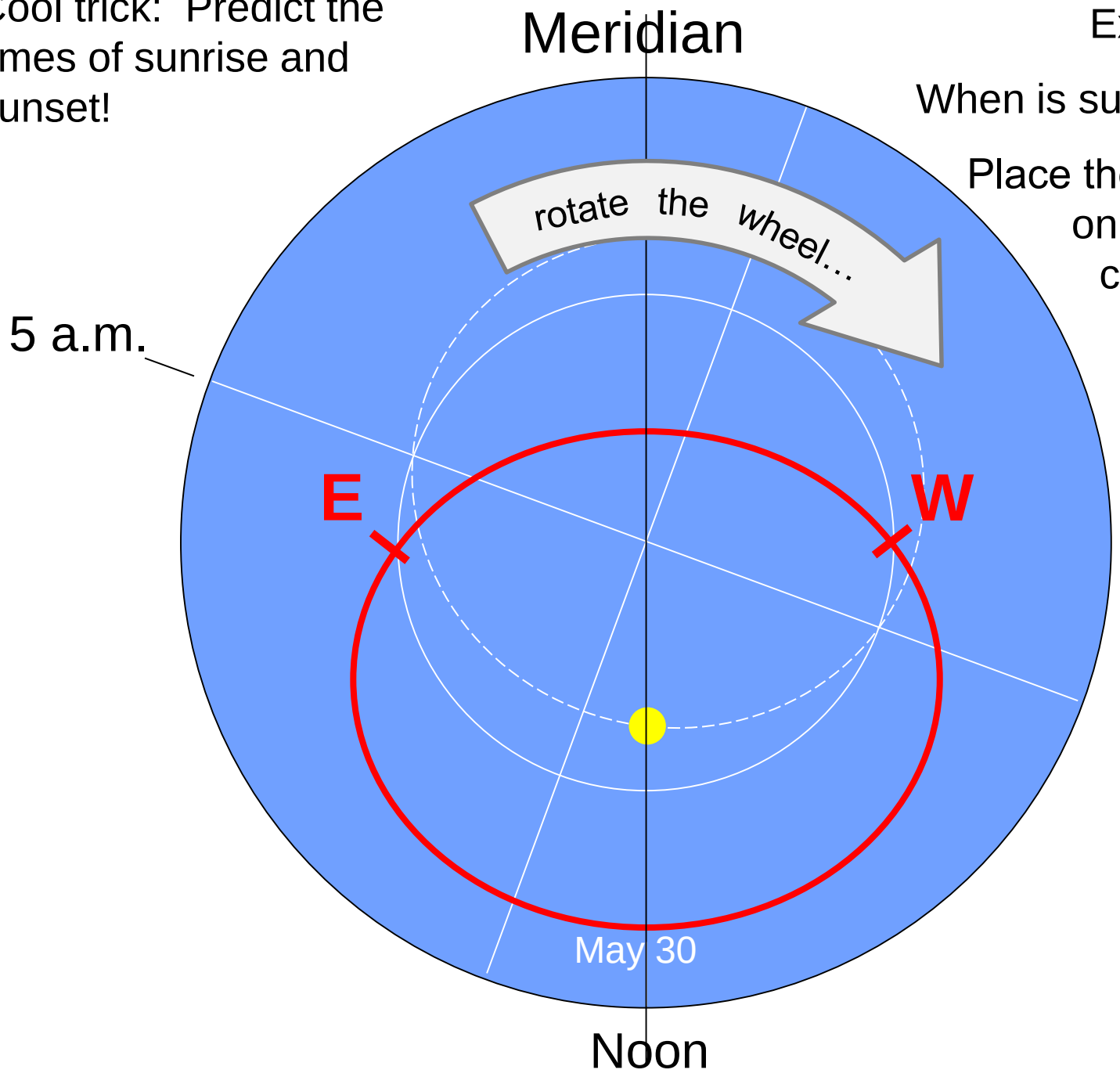
Adding the Sun to the Planisphere

Use hole punchers to punch out a small sticky dot from a post-it note. Then place the Sun in an appropriate position on the star wheel. The Sun is always on the ecliptic – use the dates on the edge of the wheel to determine where.



For example, the Sun is here on May 30th. Notice that correctly puts the Sun on the Meridian at noon mean solar time (which makes sense!) You can determine that it is in the constellation Taurus at coordinates 4^h30^m, 22º.

Cool trick: Predict the times of sunrise and sunset!

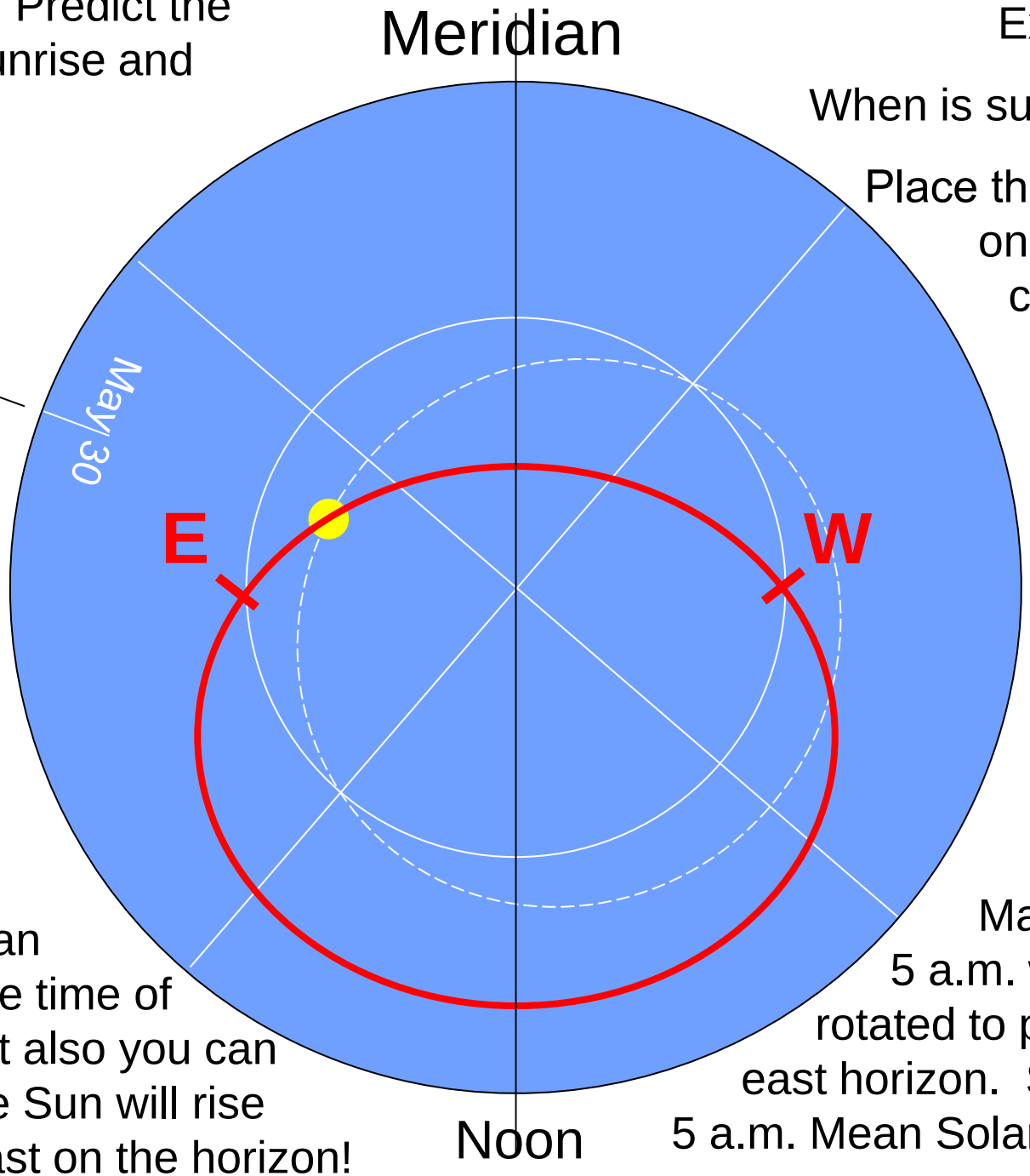


Example:

When is sunrise on May 30?

Place the “sticky-dot Sun” on the ecliptic at the correct location for this date. Then rotate the wheel until the Sun is centered on the east side of the horizon…

Cool trick: Predict the times of sunrise and sunset!



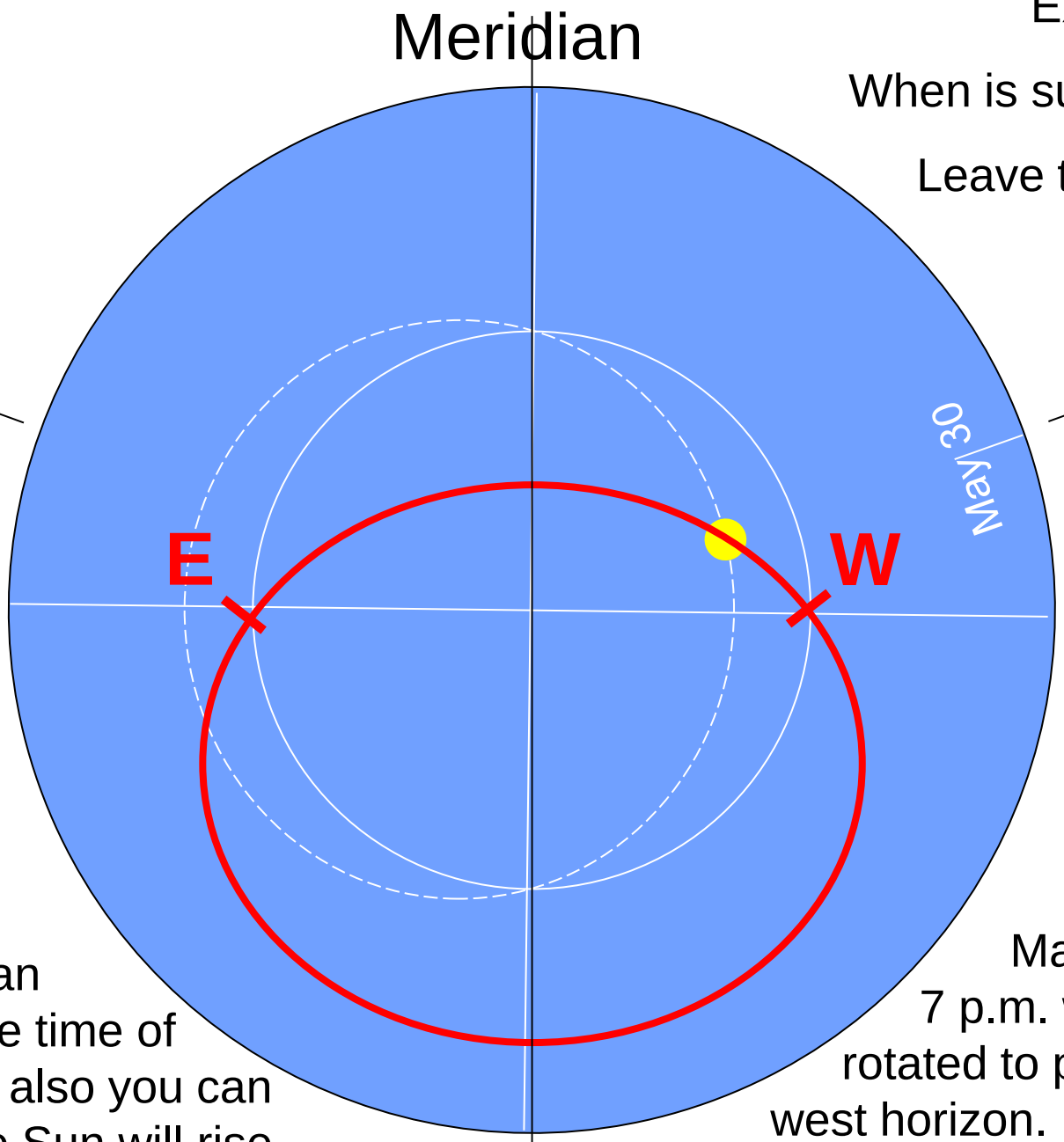
Example:

When is sunrise on May 30?

Place the “sticky-dot Sun” on the ecliptic at the correct location for this date. Then rotate the wheel until the Sun is centered on the east side of the horizon…

…notice the date May 30 lines up with 5 a.m. when the wheel is rotated to put the Sun on the east horizon. Sunrise is approx. 5 a.m. Mean Solar Time on May 30!

Not only can you find the time of sunrise but also you can tell that the Sun will rise north of east on the horizon!



Example:

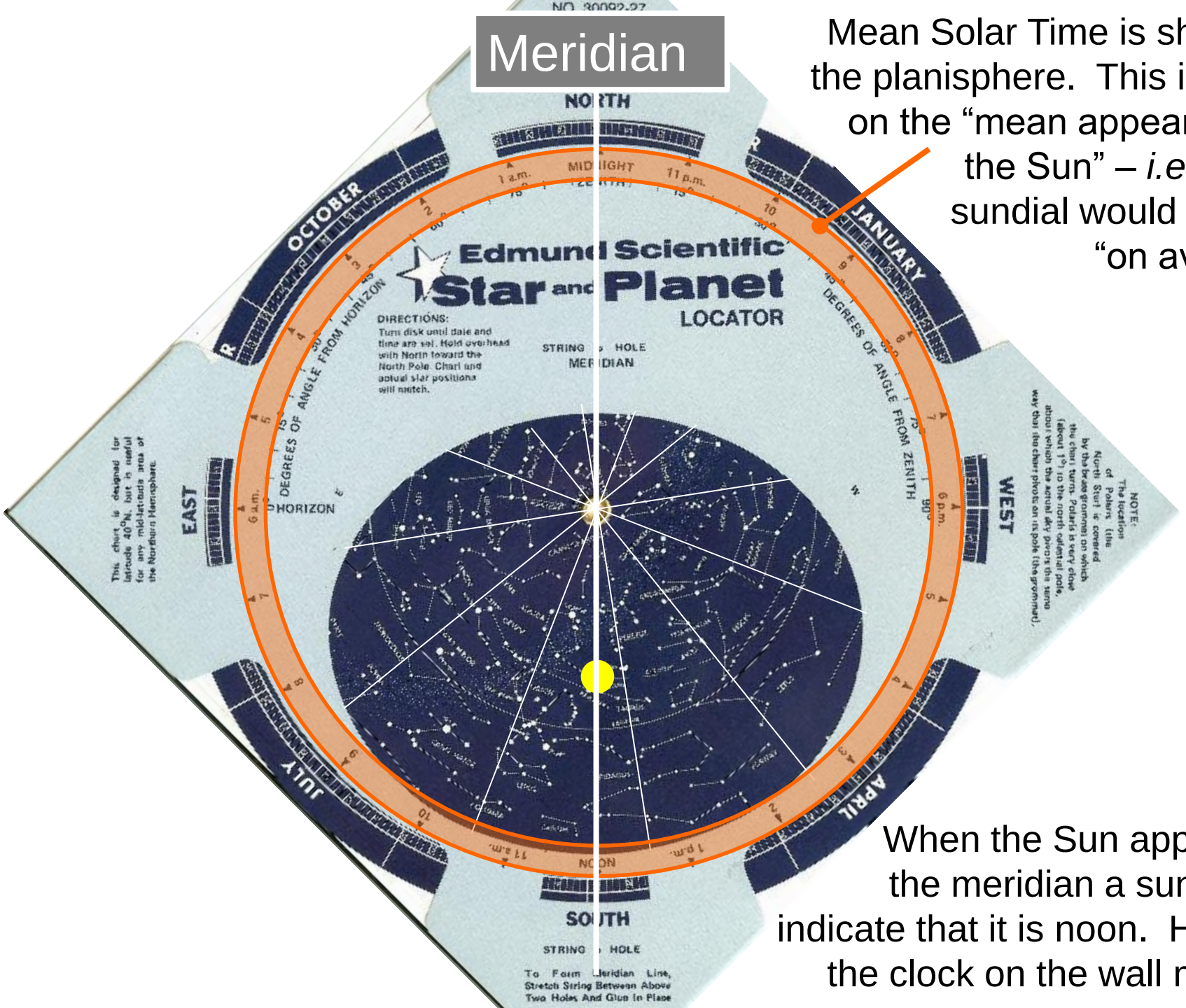
When is sunset on May 30?

Leave the sticky dot Sun at the same spot on the ecliptic.

Rotate the wheel until the Sun is centered on the west side of the horizon…

…notice the date May 30 lines up with 7 p.m. when the wheel is rotated to put the Sun on the west horizon. Sunset is approx. 7 p.m. Mean Solar Time on May 30!

Not only can you find the time of sunset but also you can tell that the Sun will rise north of west on the horizon!

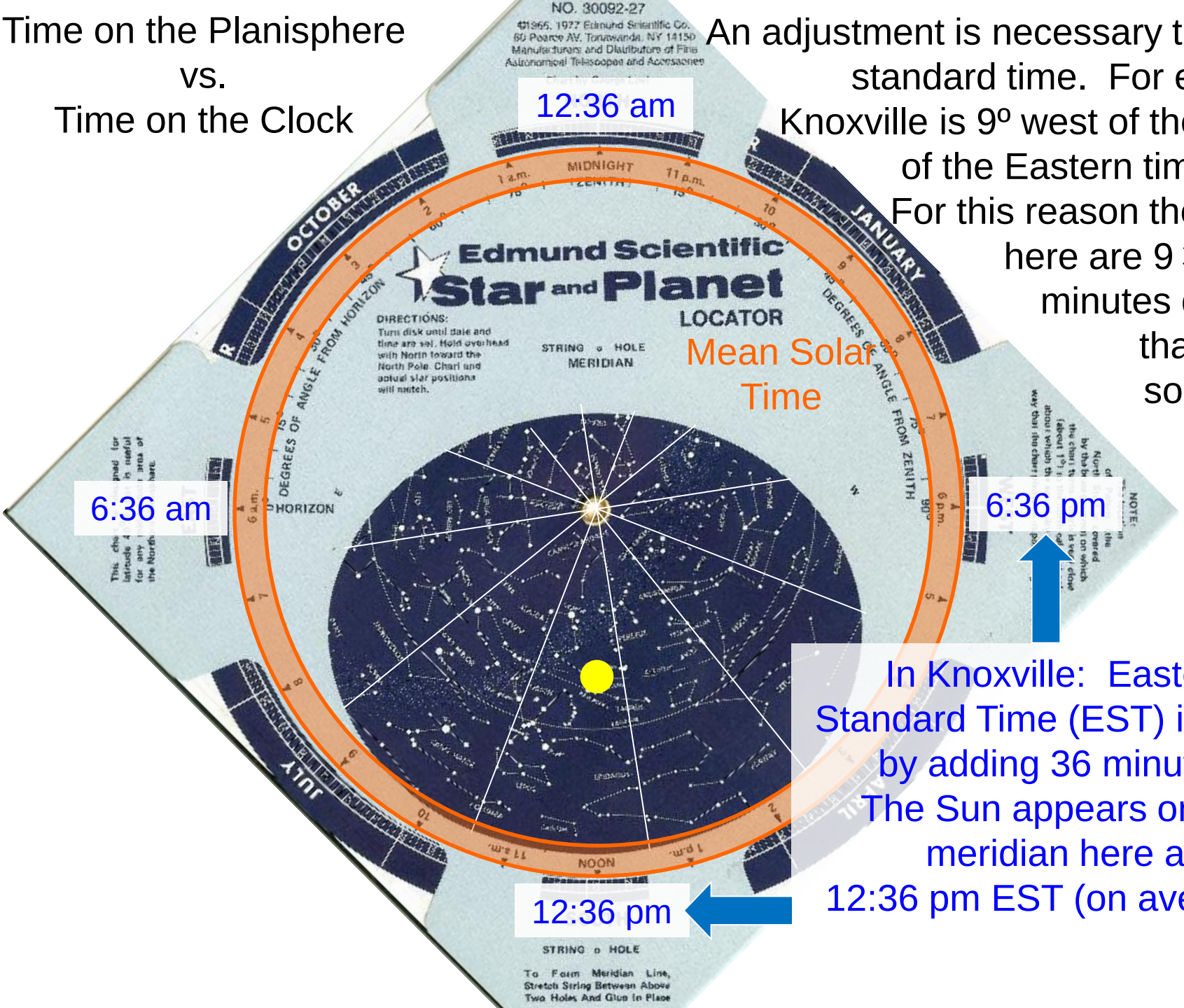


Mean Solar Time is shown on the planisphere. This is based on the "mean appearance of the Sun" – *i.e.* what a sundial would indicate "on average".

When the Sun appears on the meridian a sundial will indicate that it is noon. However the clock on the wall may not!

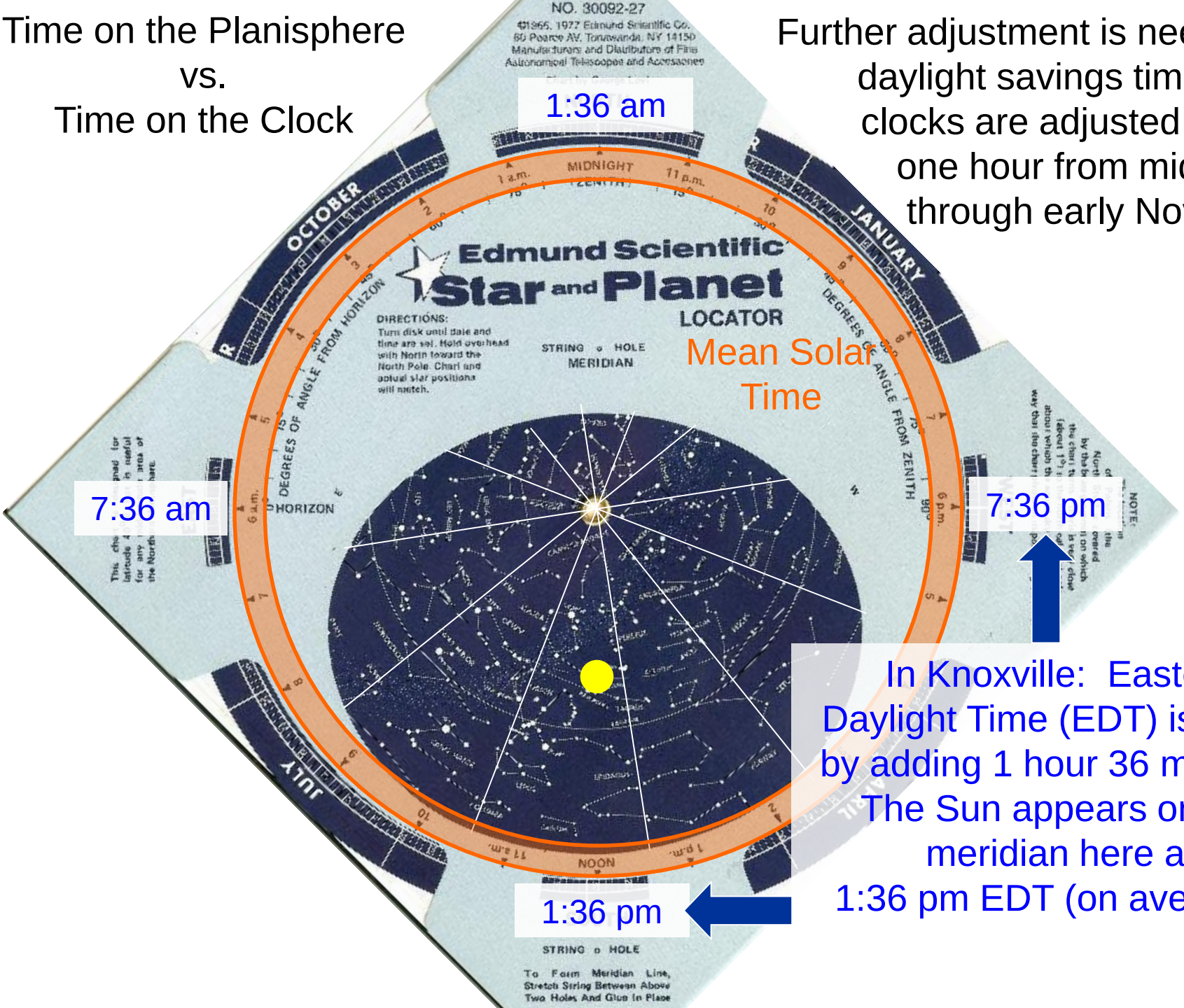
Time on the Planisphere
vs.
Time on the Clock

An adjustment is necessary to match standard time. For example Knoxville is 9º west of the center of the Eastern time zone. For this reason the clocks here are 9 × 4 = 36 minutes different than mean solar time.



In Knoxville: Eastern Standard Time (EST) is found by adding 36 minutes. The Sun appears on the meridian here at 12:36 pm EST (on average).

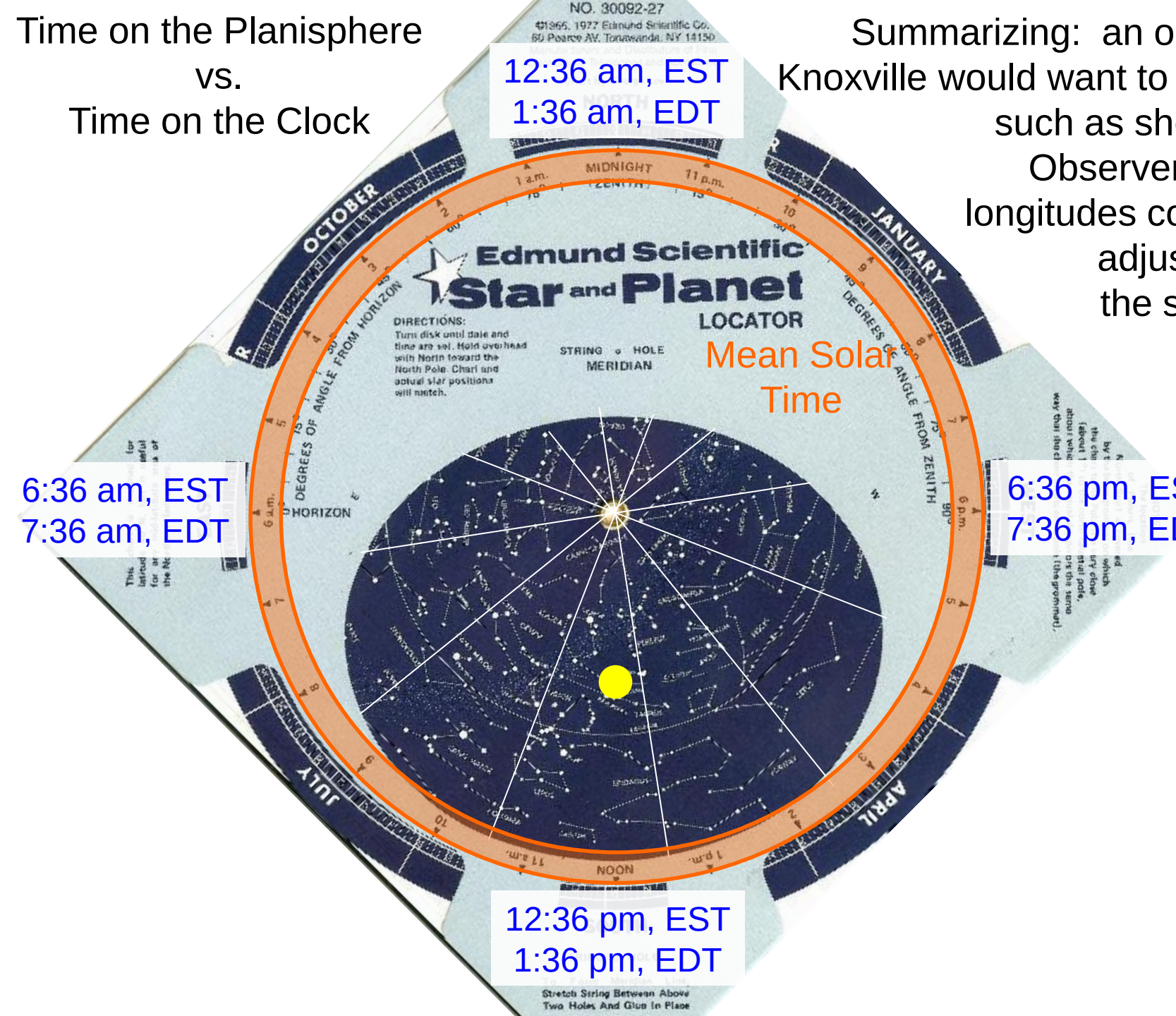
Time on the Planisphere
vs.
Time on the Clock



Further adjustment is needed for daylight savings time! Most clocks are adjusted forward one hour from mid-March through early November.

In Knoxville: Eastern Daylight Time (EDT) is found by adding 1 hour 36 minutes. The Sun appears on the meridian here at 1:36 pm EDT (on average).

Time on the Planisphere
vs.
Time on the Clock



12:36 am, EST
1:36 am, EDT

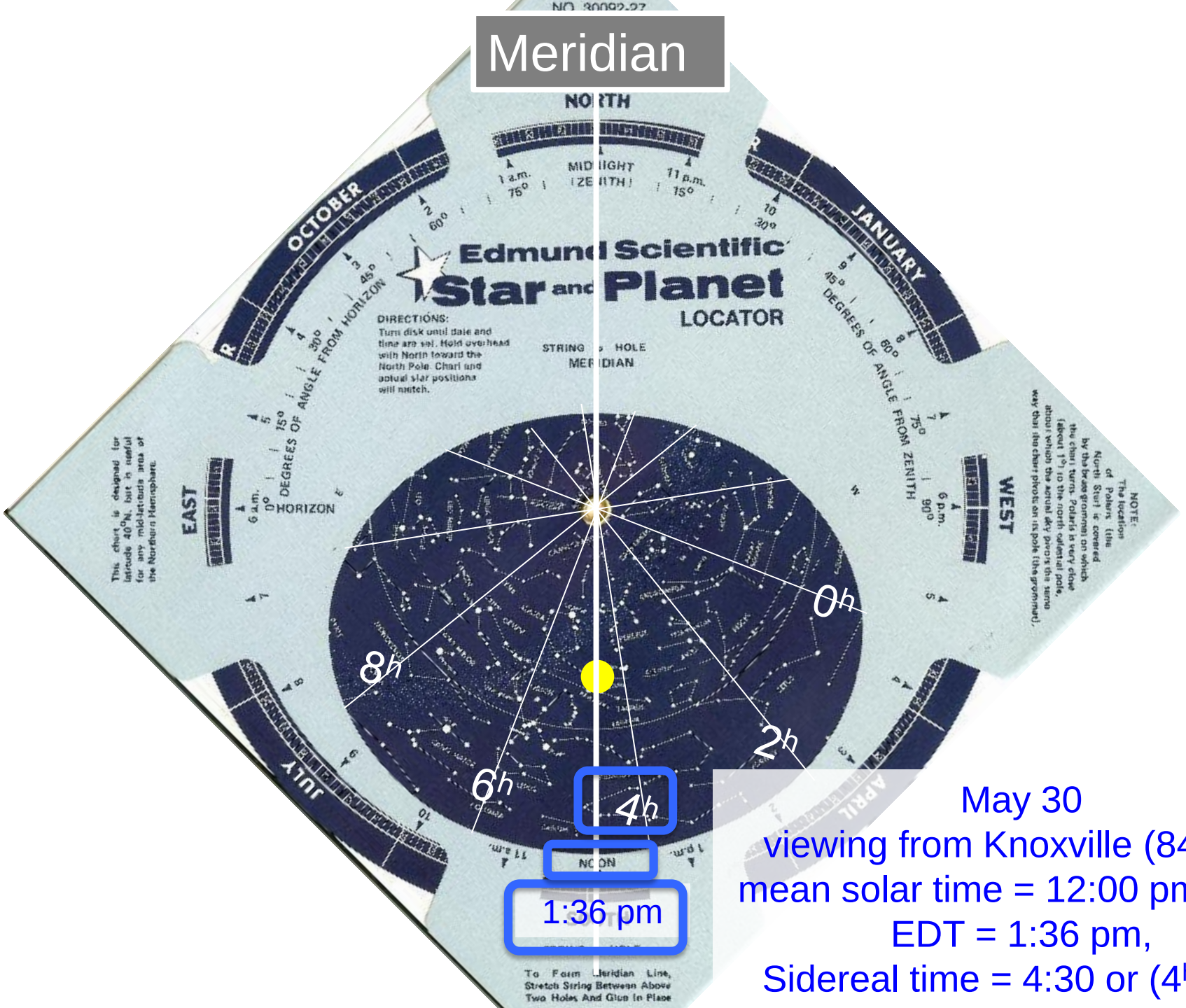
Mean Solar Time

6:36 am, EST
7:36 am, EDT

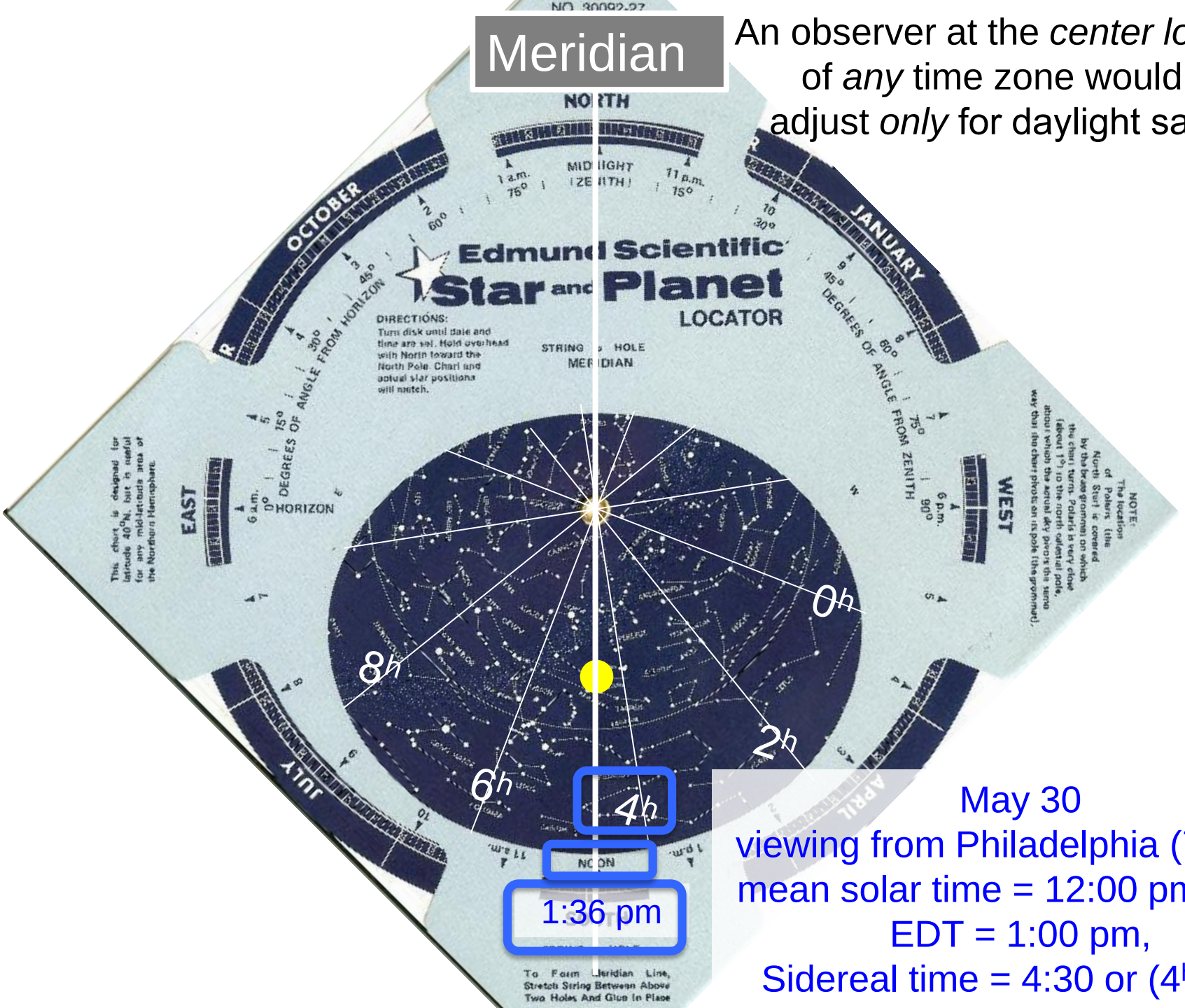
6:36 pm, EST
7:36 pm, EDT

12:36 pm, EST
1:36 pm, EDT

Summarizing: an observer in Knoxville would want to use times such as shown here. Observers at other longitudes could make adjustments in the same way.



May 30
viewing from Knoxville (84º W):
mean solar time = 12:00 pm noon,
EDT = 1:36 pm,
Sidereal time = 4:30 or (4^h 30^m)



An observer at the *center longitude* of *any* time zone would have to adjust *only* for daylight savings…

May 30
viewing from Philadelphia (75º W):
mean solar time = 12:00 pm noon,
EDT = 1:00 pm,
Sidereal time = 4:30 or (4^h 30^m)


LOCATOR
DIRECTIONS:
STRING o HOLE
MERIDIAN
HORIZON
NOON
WEST
JULY
0h
2h
4h
6h
8h
9:36 am
4h
Sun is about “half way up” the sky and is located in the constellation Cancer.
July 30
viewing from Knoxville (84º W):
mean solar time = 8:00 am,
EDT = 9:36 am,
Sidereal time = 4:30 or (4h 30m)

Practice with Enhanced Planisphere

1. Find the times of **sunrise** and **sunset** and the **constellation** in which the Sun is found:
   (a) Sept. 22
   (b) Nov. 10
   (c) Aug. 1
2. Find the approximate sidereal time for mean solar time 10 pm, February 14.
3. Find the approximate sidereal time of sunrise on Mar. 22.
4. Find date(s) on which sunset is 6:00 pm EST in Knoxville and give the Sun's approximate right ascension and declination.

1. a. 6:00 am – 6:00 pm (7:36 am – 7:36 pm EDT) Virgo b. 7:00 am – 5:00 pm (7:36 am – 5:36 pm EST) Libra c. 4:50 am – 7:10 pm (6:26 am – 8:46 pm EDT) Cancer 2. 7:30 (7^h 20^m) 3. 18:00 (18^h 00^m) 4. February 28; 22^h 06^m, – 9°