

AGA0414

Coordinate Systems

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How do you know how to come to class?

- Class is
 - in Brazil
 - São Paulo
 - USP
 - Cidade Universitaria
 - IAG
 - Aula XXX
 - Or
 - Latitude
 - Longitude
 - Elevation
- At 2pm

Space-time

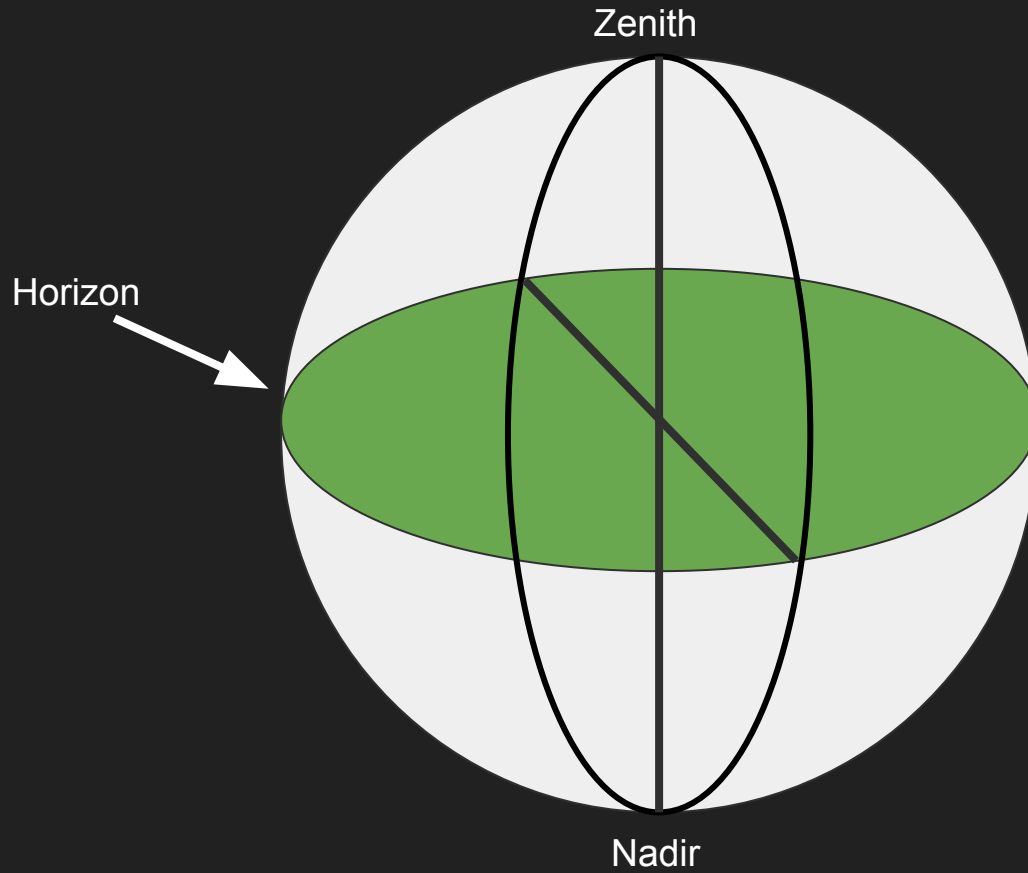
One point in space-time is defined by 3 spatial coordinates and 1 temporal coordinate.

Time

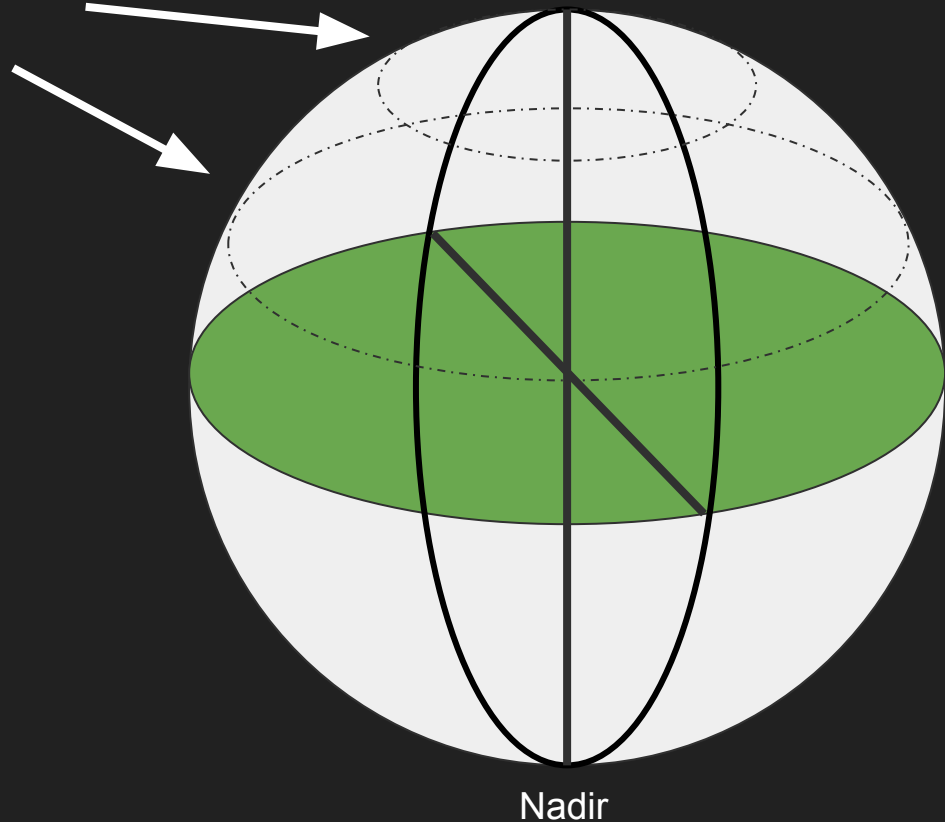
Second law of thermodynamics: entropy **MUST** increase.

What is time?

Let us start by defining **LOCAL** “noon” or “mid-day”



Stars never rise
nor set

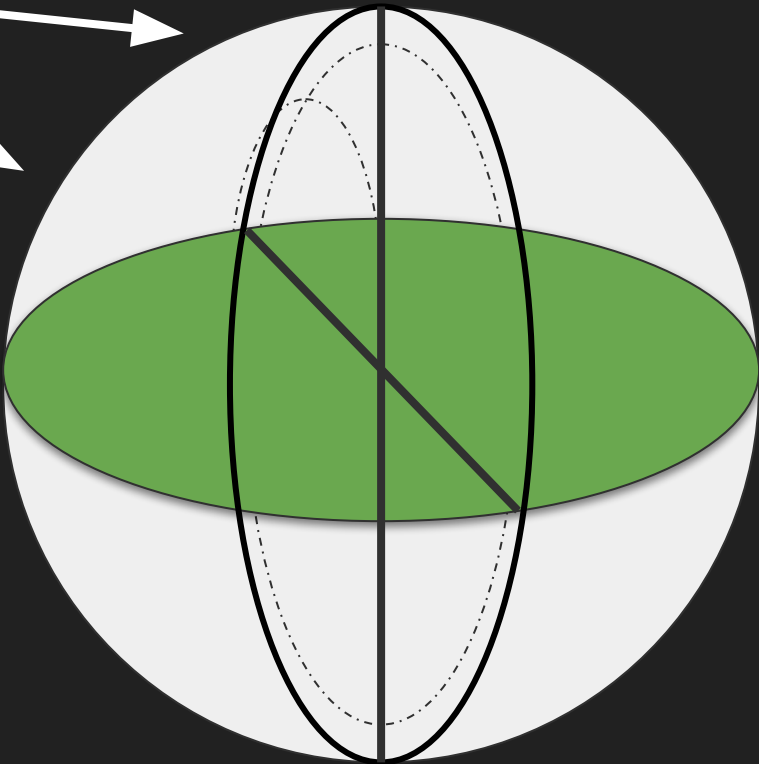


For an observer at one of the poles
of the Earth

For an observer at the Equator

All stars rise and set

Zenith



The place where stars rise is called "East"

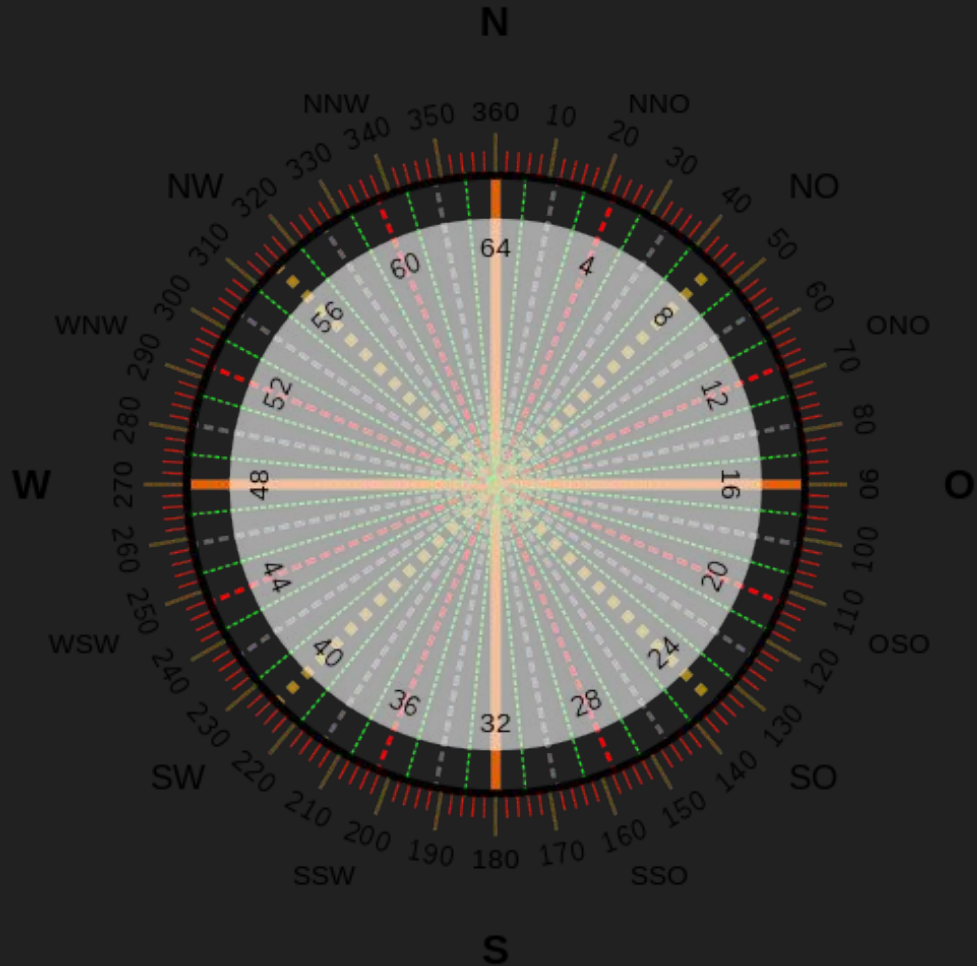
The place where stars set is called "West"

Nadir

Compass Rose

Once we defined East and West: we define North-South as the perpendicular axis.

This is Earth's rotation axis.



What happens if we are not at the Pole
or at the Equator?

If the polar axis at the pole is vertical
while it is horizontal at the Equator...

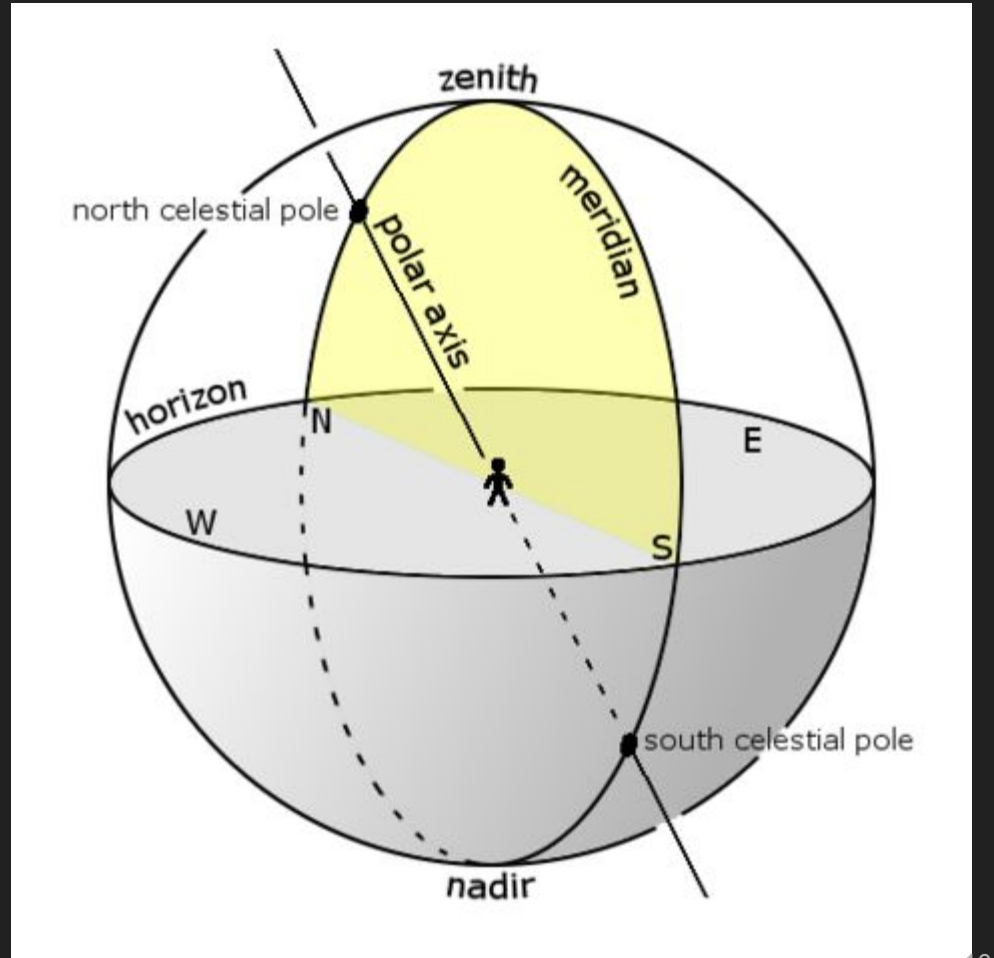
...the relation between the altitude of the
pole and the longitude of our observing
station will be:

$$h = l$$

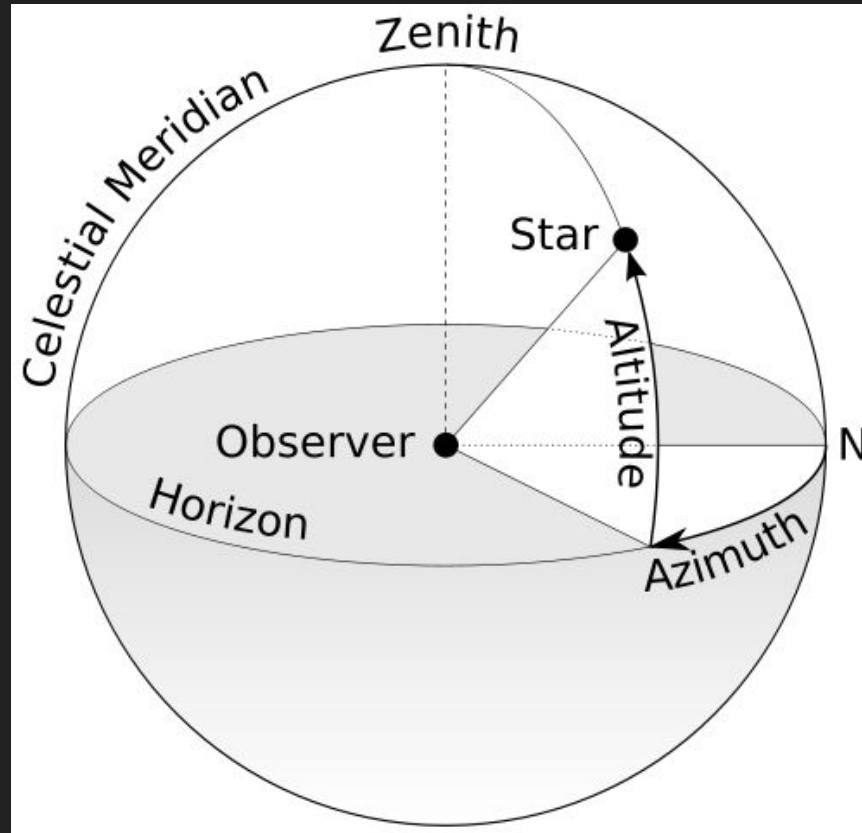
where:

h is the height above the horizon

l is the latitude of the place



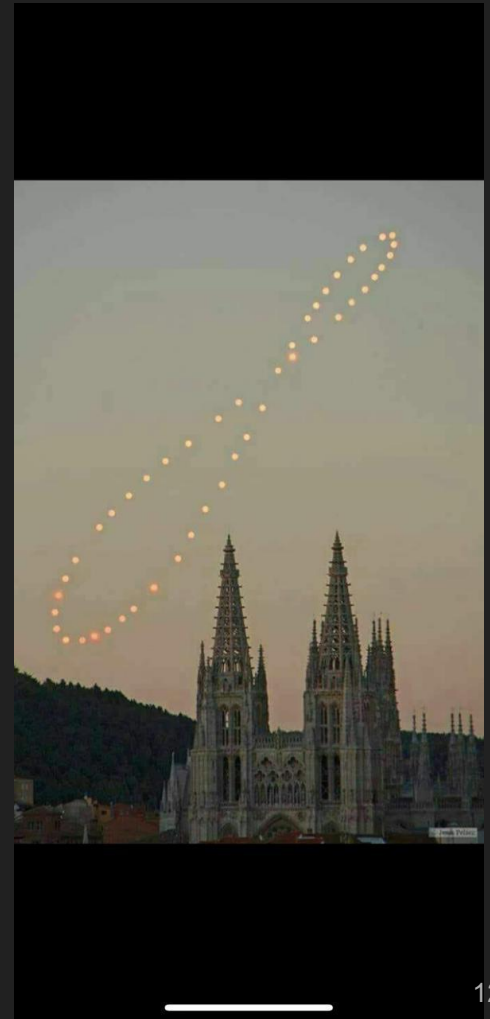
Horizontal Coordinate System



What happens if I take a picture of the Sun at noon every day of the year?

First of all: “noon” means “noon taking into account daylight saving time”

I get a figure called “analemma” => “equation of time”



Some relevant “times”

Apparent Solar Time

Sidereal Time

Mean Solar Time

Greenwich Mean Time

Universal Time

https://en.wikipedia.org/wiki/Time_standard

https://en.wikipedia.org/wiki/Barycentric_Dynamical_Time

https://en.wikipedia.org/wiki/Solar_time

https://en.wikipedia.org/wiki/Equation_of_time

<https://en.wikipedia.org/wiki/Analemma>

Solar and Sidereal Time

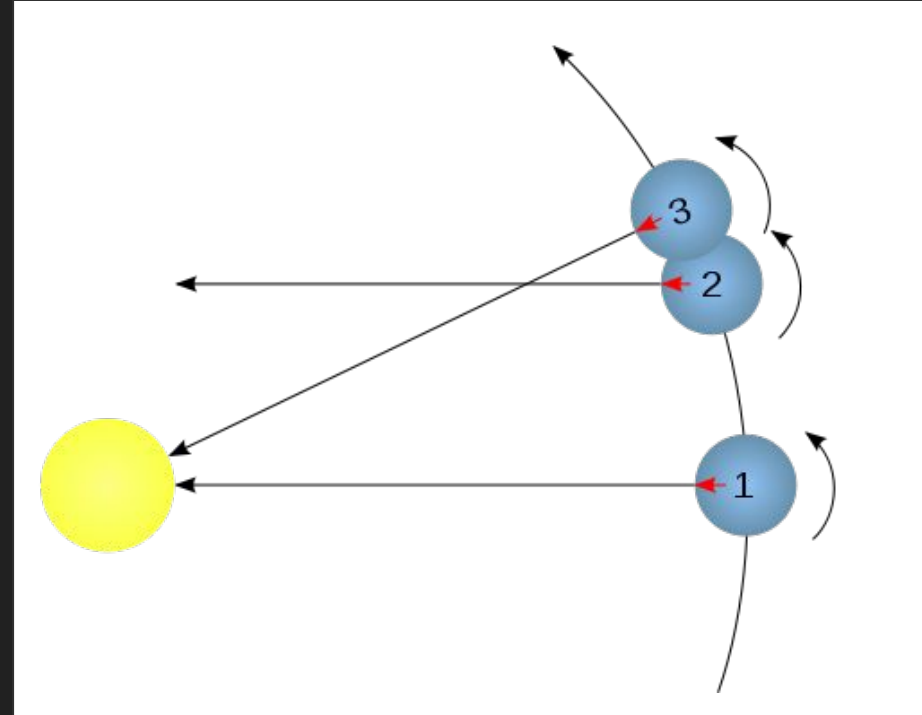
Sun culminates twice in ~24h

Between two culminations of the Sun, the Earth has moved in its orbit.

The time between two culminations of a star takes this into account.

What is the magnitude of this difference?

$\sim 24\text{h} / 365 \sim 24 * 60\text{min} / 365 \sim 4\text{min}$



Universal Time

Originally the Greenwich Meridian (Solar Mean) Time => UT

International Atomic Time (TAI) is the primary international time standard. TAI is kept by the BIPM (International Bureau of Weights and Measures), and is based on the combined input of many atomic clocks around the world, each corrected for environmental and relativistic effects.

Coordinated Universal Time (UTC) is an atomic time scale designed to approximate Universal Time. UTC differs from TAI by an integral number of seconds. UTC is kept within 0.9 second of UT1 by the introduction of one-second steps to UTC, the "leap second". To date these steps have always been positive.

Julian Day (JD)

count of days elapsed since Greenwich mean noon on 1 January 4713 B.C.

Modified Julian Day (MJD)

$$\text{MJD} = \text{JD} - 2400000.5$$

Star Date

fictional system of time measurement developed for the television and film series *Star Trek* . the general idea resembles the Julian date

Excercises

Draw the analemma for São Paulo and Rome

Draw the azimuth of the Sun at sunset over the year in São Paulo.

Compute the JD, MJD and the position of the Sun for the next lecture