## AGA5802 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 2 pm


## 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"


For an observer at one of the poles


For an observer at the Equator
All stars rise and
set

The place where stars set is called "West"

Zenith


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 latitude of our observing station will be:
$\mathrm{h}=\mathrm{l}$
where:
$h$ is the height above the horizon I is the latitude of the place


## Horizontal Coordinate System



## Some relevant "times"

Apparent Solar Time

Sidereal Time
Mean Solar Time
Greenewich 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 $\sim 24 h$
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?
~24h / $365 \sim 24$ * 60min / 365 ~ 4min


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"


## analemma

## Universal Time

Originally the Greenwich Meridian (Solar Mean) Time => UT
International Atomic Time (TAI) is the primary international time standard. TAl 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)

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

## Star Date

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

## Stellarium!

## 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
Compute when is Carnival in 2021 and 2022

## How Carnival Relates with Astronomy

- Easter
- Sunday
- The first Sunday after the first Full Moon after the (Northern Hemisphere) Spring Equinox
- Ash Wednesday is 46 days before Easter Sunday
- "Lent" [en], "Quaresma" [pt], "Quaresima" [it] are the 46 days before Easter (it is a period of fasting)
- Mardi Gras is the day before Ash Wednesday

