

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

Sky Coordinates

Earth Coordinates - Equator



<https://www.nasa.gov/audience/forstudents/k-4/dictionary/Equator.html>

Earth Coordinates - Meridian Zero



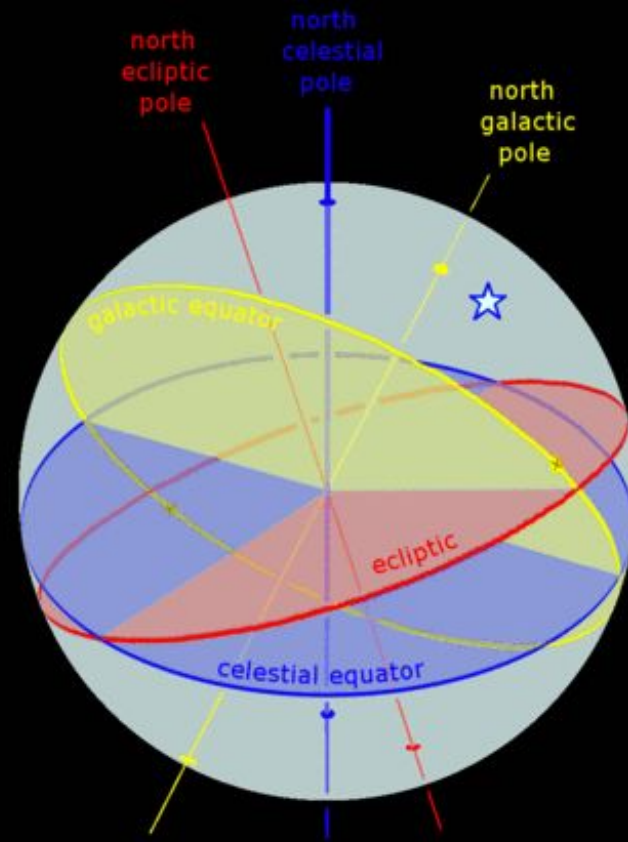
[https://en.wikipedia.org/wiki/Longitude_\(book\)](https://en.wikipedia.org/wiki/Longitude_(book))

Relevant planes

Equator

Ecliptic

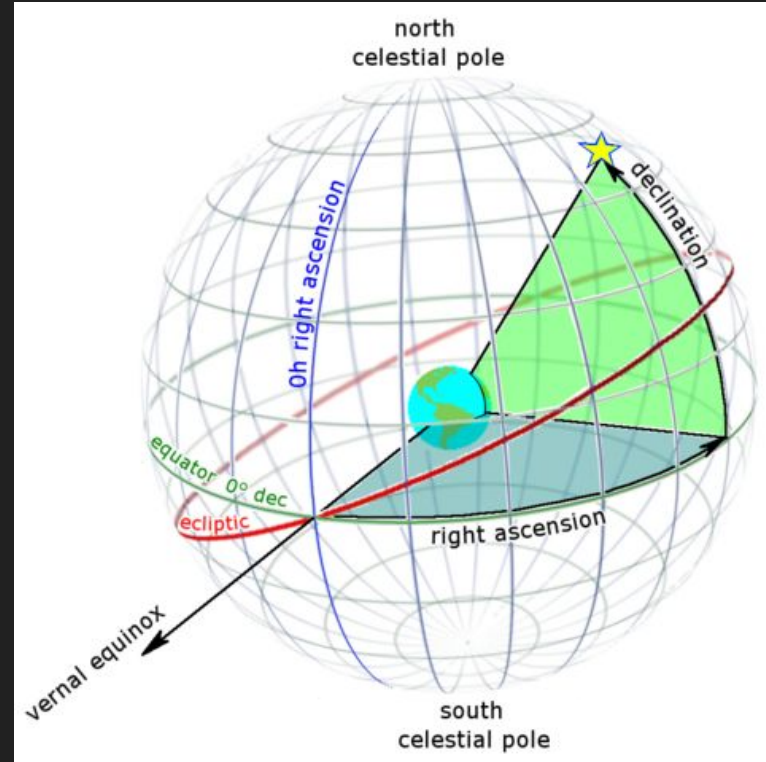
Milky Way



Declination

Angular distance from the celestial equator

Celestial poles have $\delta = \pm 90^\circ$

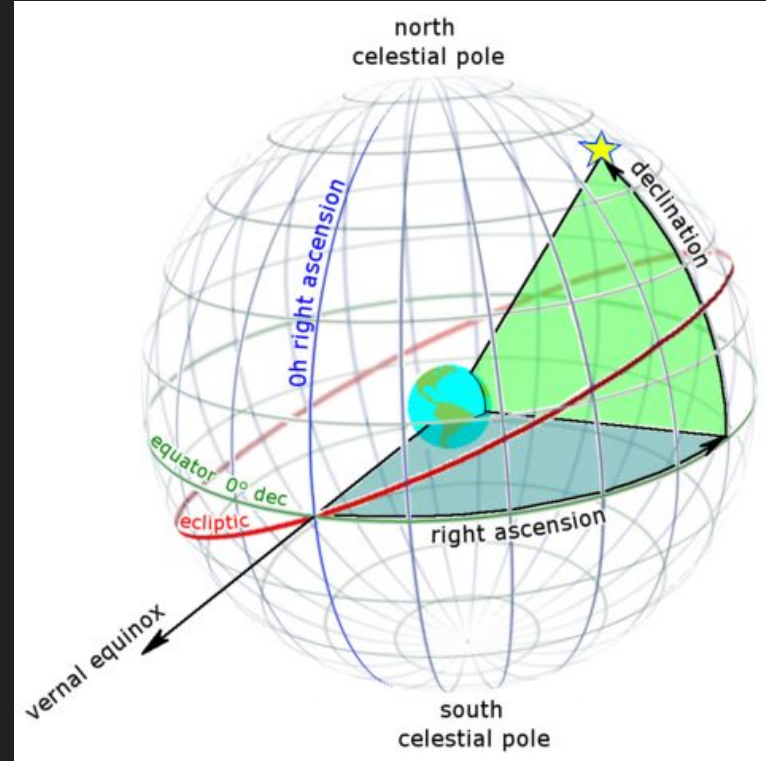


Declination of zenith

Celestial poles have $\delta = 90^\circ$

If the height above the horizon of the celestial pole equals the longitude of the place: can we infer the declination of zenith?

$$\delta_z = \varphi$$



The γ point and Right Ascension (α)

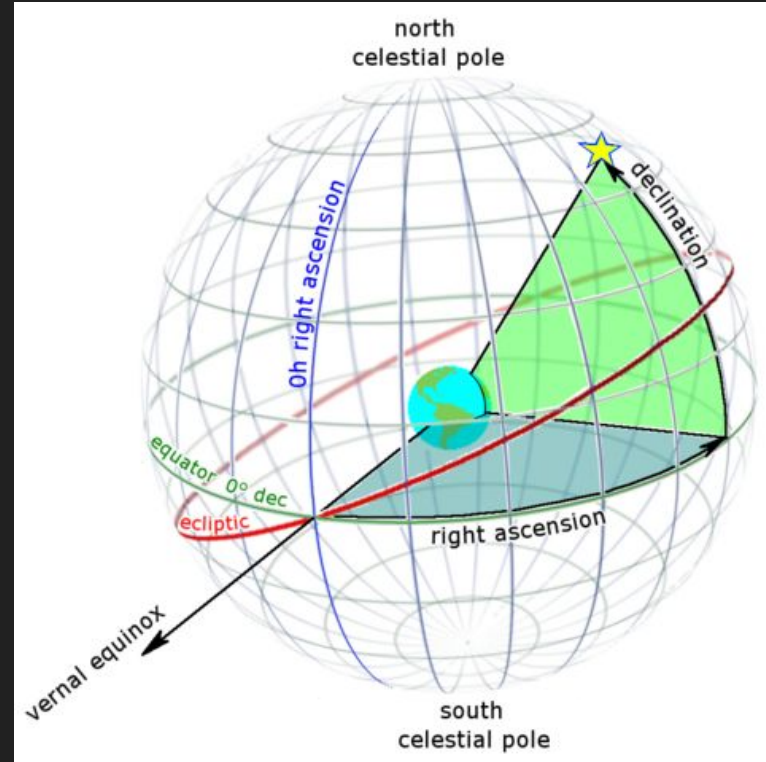
The celestial equator and the ecliptic cross in two points.

One of these points is the “vernal point”.

It is the position of the Sun on Mar21 (aprox).

ON MAR21, THE SUN HAS RA = 0h

$$2 \pi \text{ radians} = 360^\circ = 1 \text{ day} = 24\text{h}$$

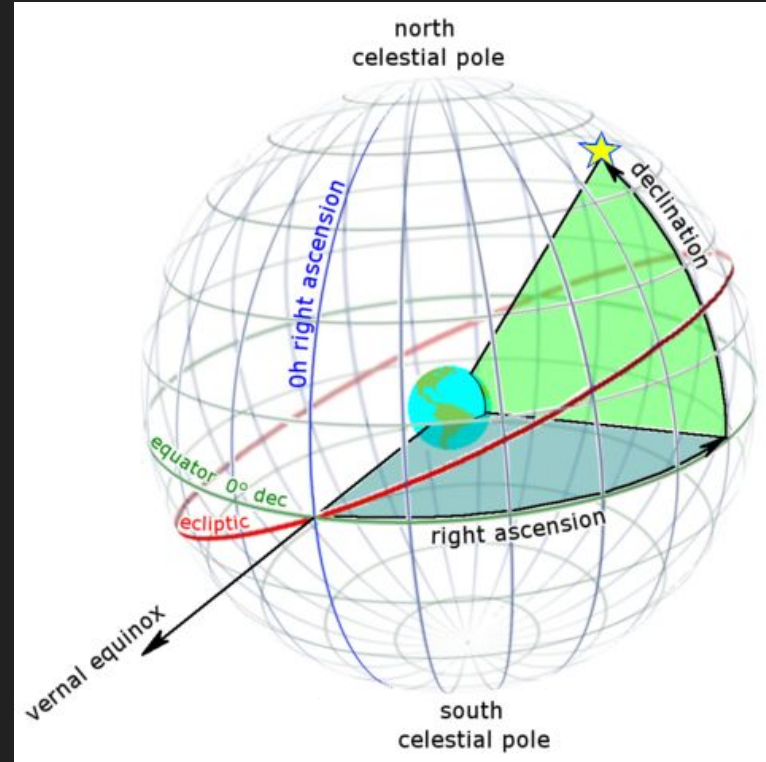


The Hour Angle

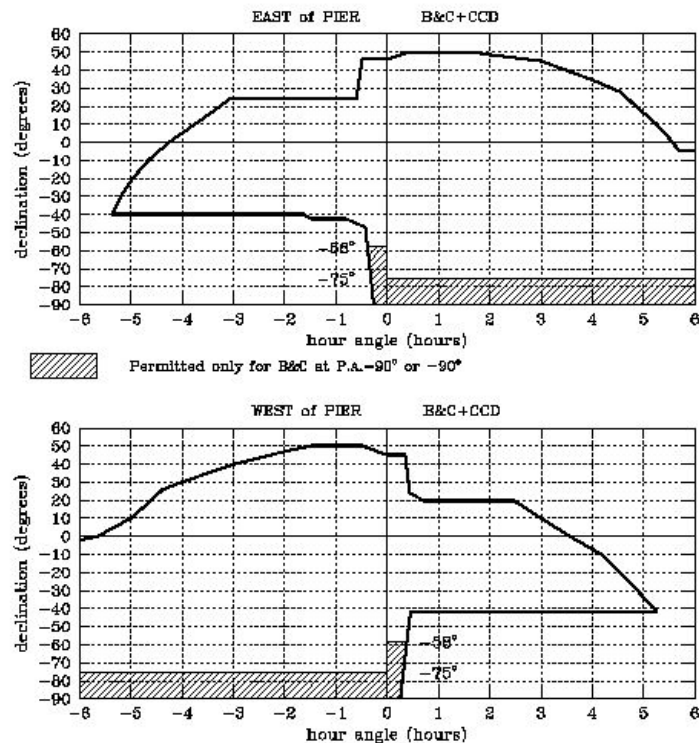
Local Sidereal Time is the (sidereal) time since the γ point has passed the local meridian.

The hour angle (HA) is:

$$HA_{\text{object}} = LST - \alpha_{\text{object}}$$



Pointing Limits of an Equatorial Mount



The Right Ascension of zenith

In the middle of the night (which is **NOT** midnight):

On Mar21, $\alpha_{\text{Sun}} \sim 0\text{h}$

Since Sun is at nadir, at that moment, the $\alpha_{\text{zenith}} \sim 12\text{h}$

Since the Sun “moves” around the Ecliptic in a year ($360^\circ = 24\text{h} = 12 \text{ months}$), it means that α_{zenith} changes by 2hours/month.

On Dec 21, α_{zenith} is 0h

Coordinates of zenith

What are the coordinates of zenith (in the middle of the night) on

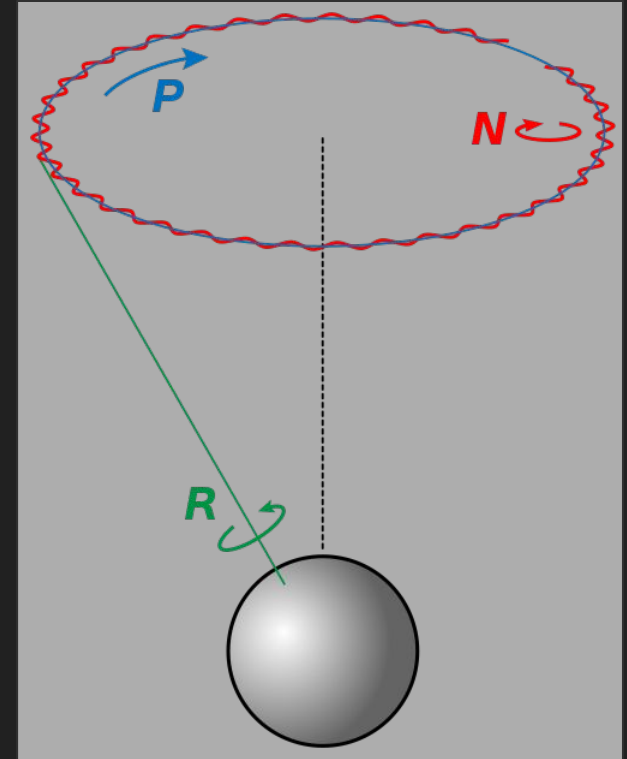
Jun 21

Sep 21

Today

Movements of the Earth

Revolution	1 year
Rotation	1 day
Precession	25,000 years
Nutation	18.6 years



Reference Systems

FK4

Based on bright stars at B1950.

FK5

Based on bright stars at J2000.

ICRS

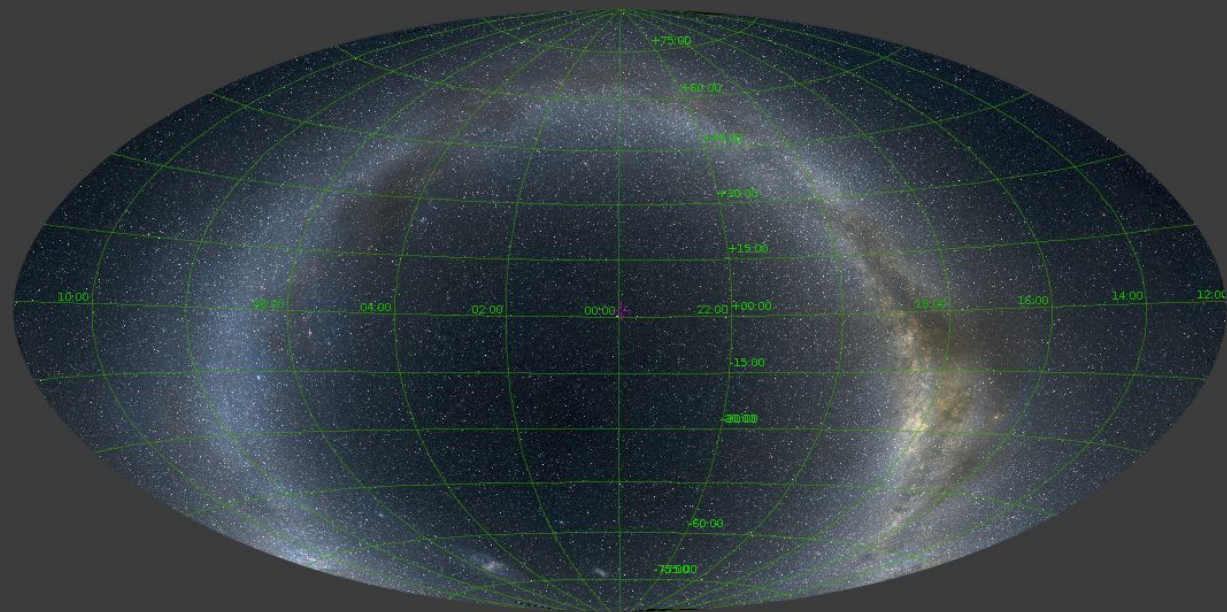
Based on radio observations of quasars

Epoch and Equinox

Define the origin of our coordinate system.

Equinox refers to the position of the vernal point.

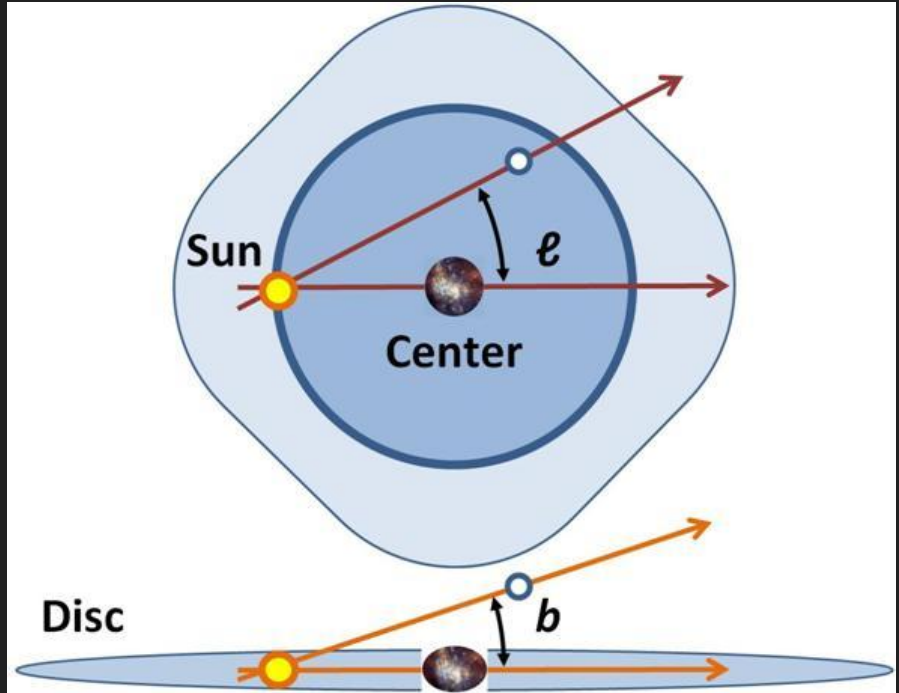
Epoch refers to the position of a moment in time.

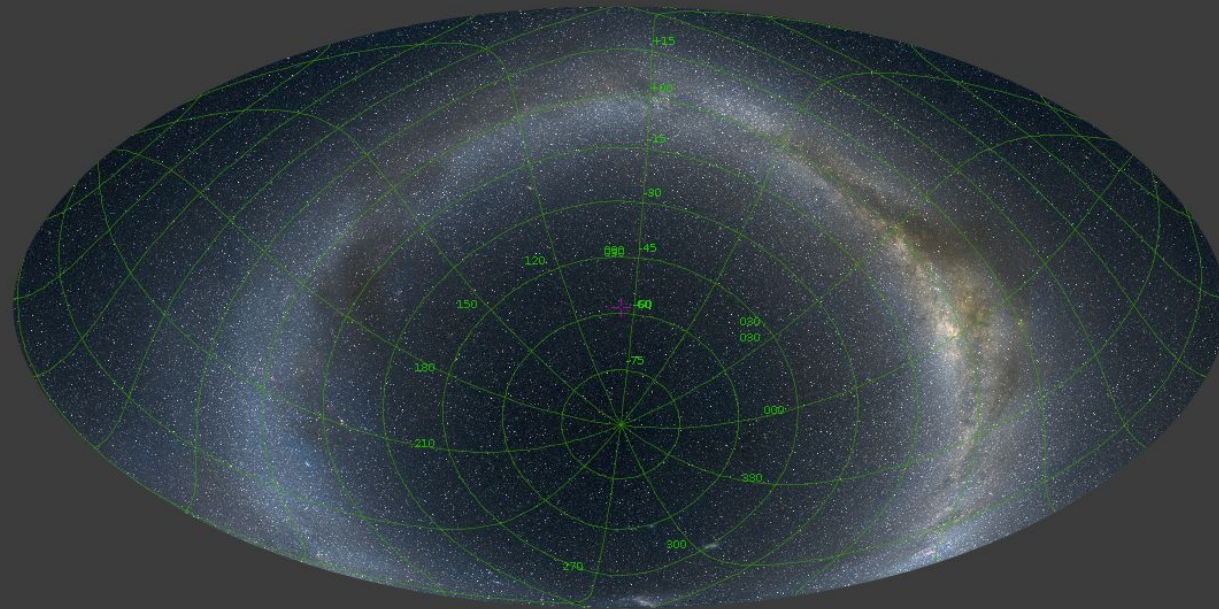


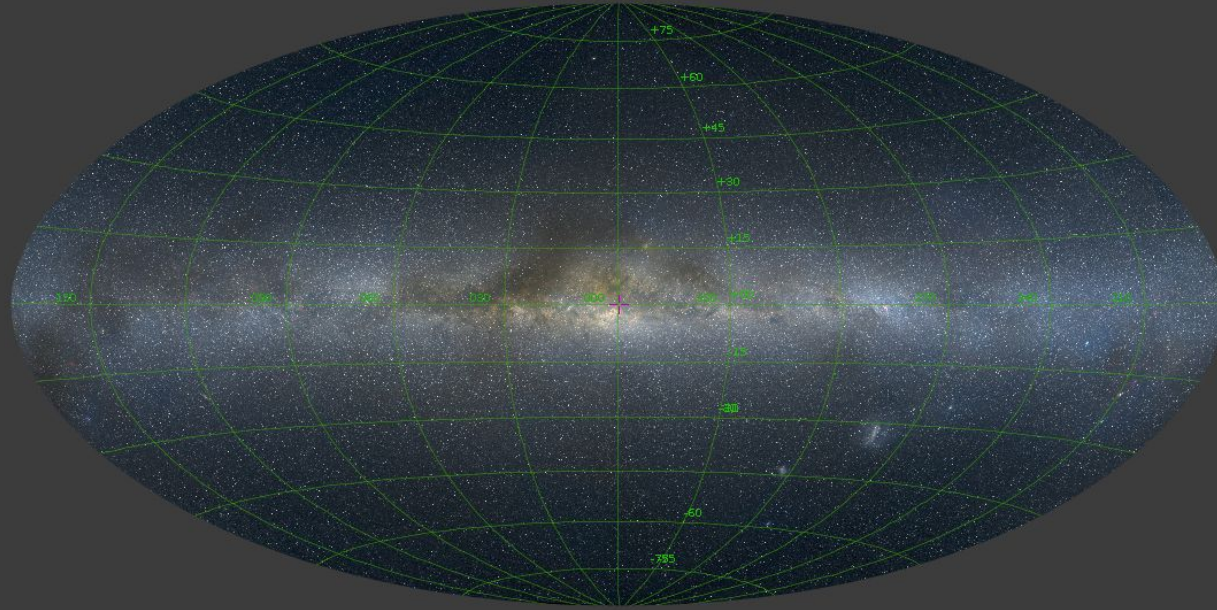
Galactic Coordinates

Galactic longitude - l

Galactic latitude - b



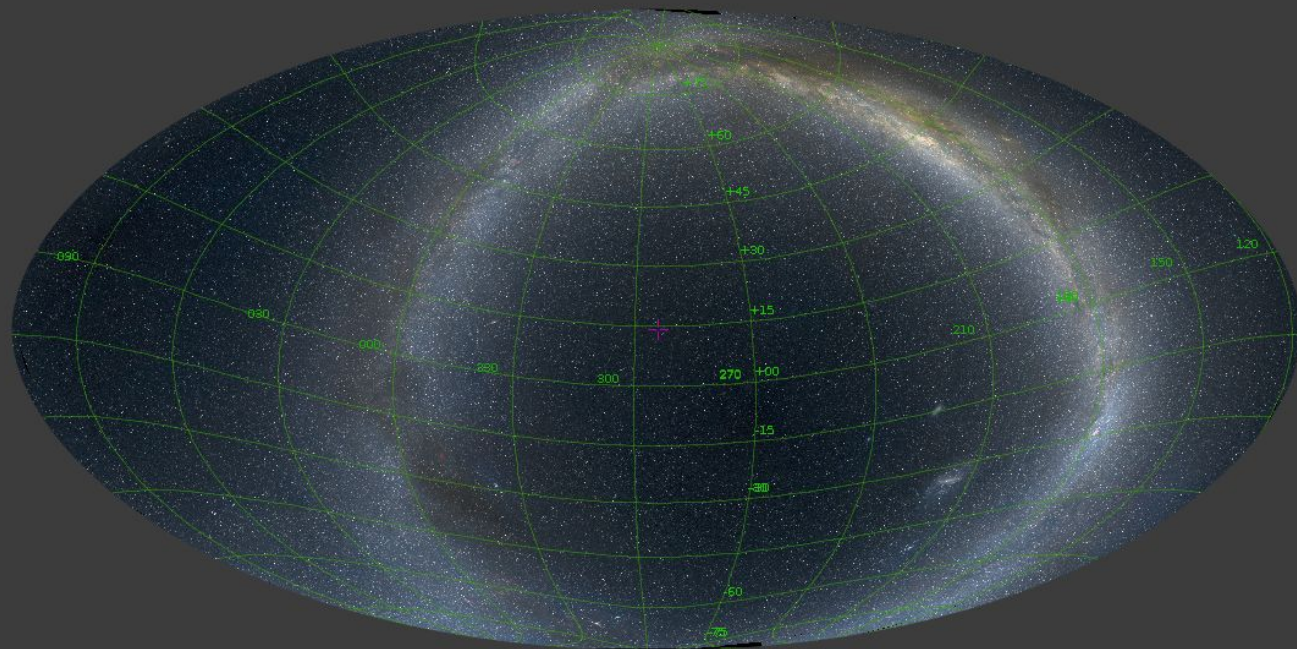




Super-Galactic Coordinates

Very little used.

Designed to have its equator aligned with the **supergalactic plane**, a major structure in the local universe formed by the preferential distribution of nearby galaxy clusters (such as the Virgo cluster, the Great Attractor and the Pisces-Perseus supercluster) towards a (two-dimensional) plane



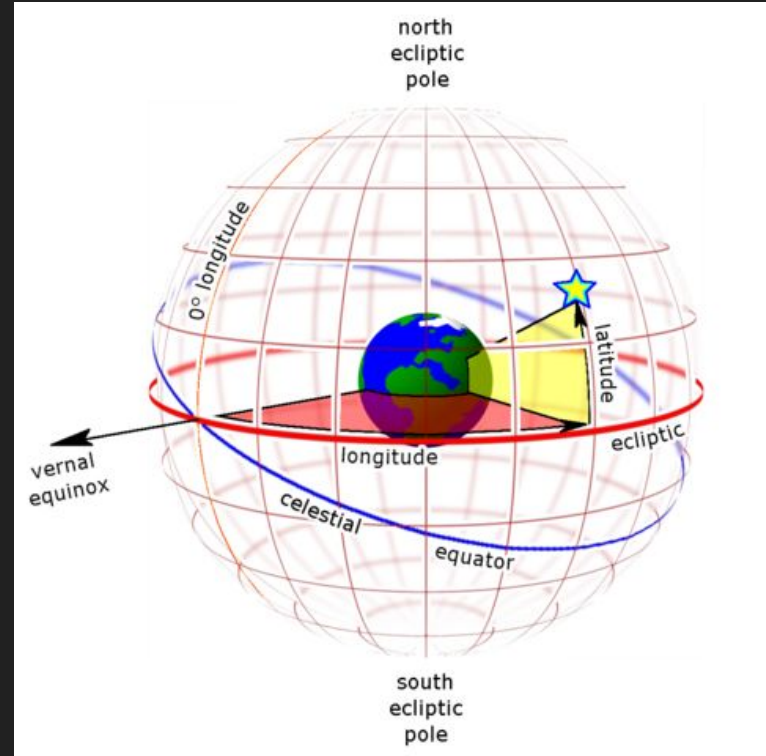
Ecliptic Coordinates

Used for objects in the Solar System

Ecliptic as main plane

Centred on Earth OR Sun

Can be either spherical or rectangular



Let's get some objects and check their coordinates

Simbad

<http://simbad.u-strasbg.fr/simbad/>

NED (NASA Extragalactic Database)

<http://ned.ipac.caltech.edu/>

John R. Thornstensen

<https://home.dartmouth.edu/faculty-directory/john-r-thorstensen>

<https://www.dartmouth.edu/~physics/labs/skycalc/flyer.html>



Staralt

<http://catserver.ing.iac.es/staralt/index.php>

Compute visibility

Compute trajectories

Programming

Do you have any experience in programming?

- FORTRAN77
- FORTRAN90
- C
- C++
- Perl
- Python 2.7
- Python 3
- IDL
- R

ESO SkyCalc

<https://www.eso.org/observing/etc/bin/gen/form?INS.MODE=swspectr+INS.NAME=SKYCALC>

pyephem

<https://rhodesmill.org/pyephem/>

In case you get lost with cities:

<https://github.com/brandon-rhodes/pyephem/blob/master/ephem/cities.py>

Yet, pyephem is now deprecated.

One should use SkyField

<https://rhodesmill.org/skyfield/>

astropy

<http://www.astropy.org/astropy-tutorials/rst-tutorials/coordinates.html?highlight=filtertutorials>

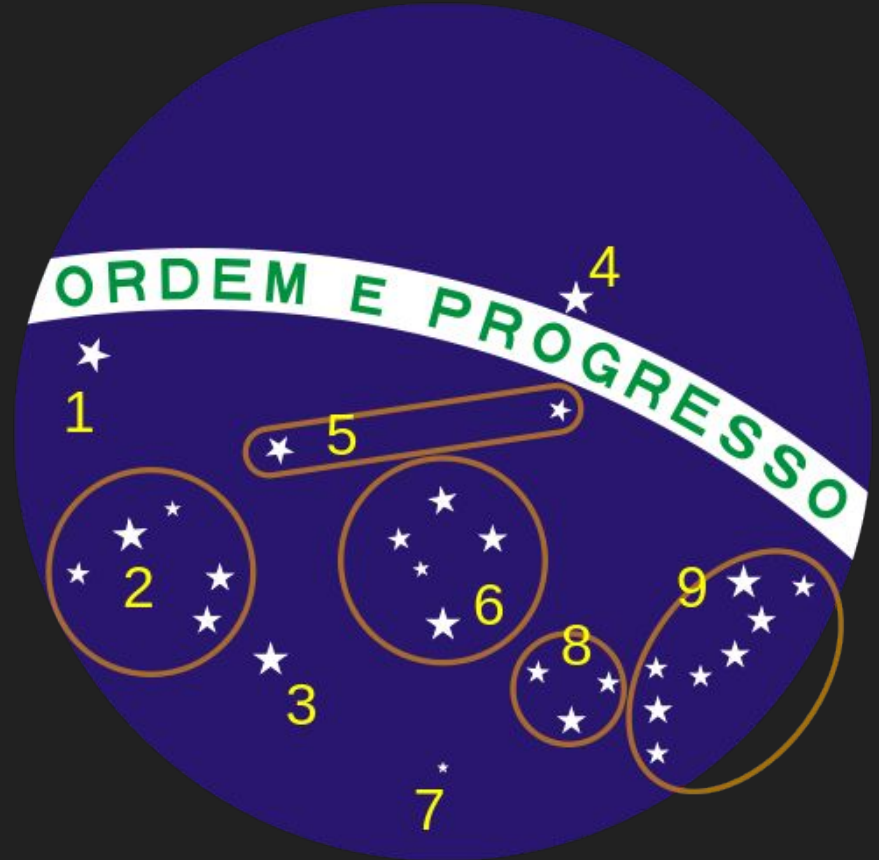
IDL

There are commands for IDL users:

<https://idlastro.gsfc.nasa.gov/contents.html>

The Flag of Brazil

the stars in the sky at Rio de Janeiro at
8:30 in the morning on 15 November
1889



https://en.wikipedia.org/wiki/Flag_of_Brazil#Stars

Excercises

- Draw the flag of Brazil for the same date but as if the capital was Natal instead of Rio
- Draw the flag of Brazil if the sky was Mar1, 2019 and the capital was São Paulo
- Draw the alt-az position of Sirius at noon over a year. Does it draw an analemma? Explain why
- Draw the azimuth of Sirius when it rises (i.e. when its altitude = 0 towards East) over the year. Does it vary? Explain why
- Install astropy and follow the tutorial
 - <http://www.astropy.org/astropy-tutorials/rst-tutorials/coordinates.html?highlight=filtertutorials>
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