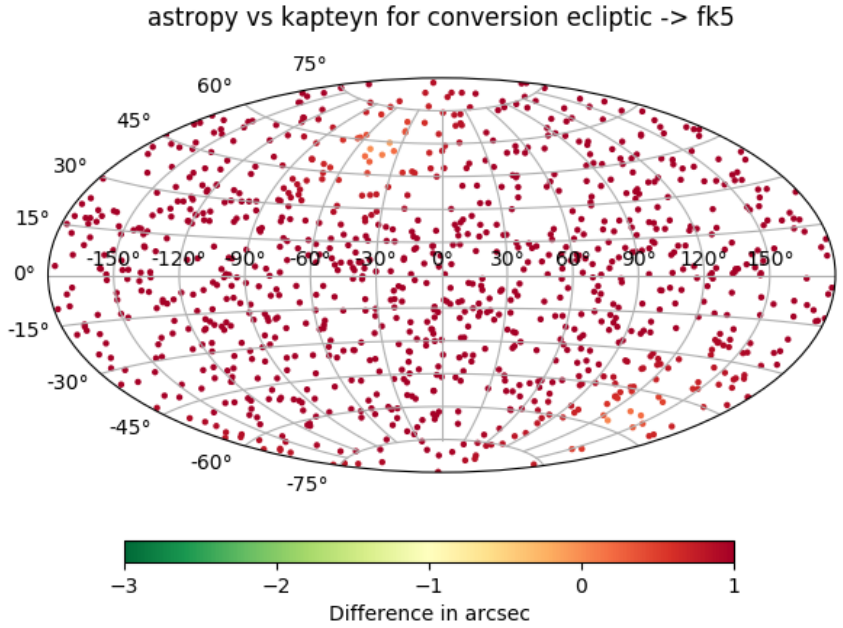
ASTR 310
Computing in Astronomy

Spring 2024

Lecture 14: Data I: Astropy: units, coordinates, times, and dates



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Topics covered in the reading

Astropy `Quantity` objects and units (`astropy.units`); see astropy docs for a list of all available units

Unit conversions (`to` method), unit equivalencies
`u.g.find_equivalent_units()`

Physical constants (`astropy.constants`)

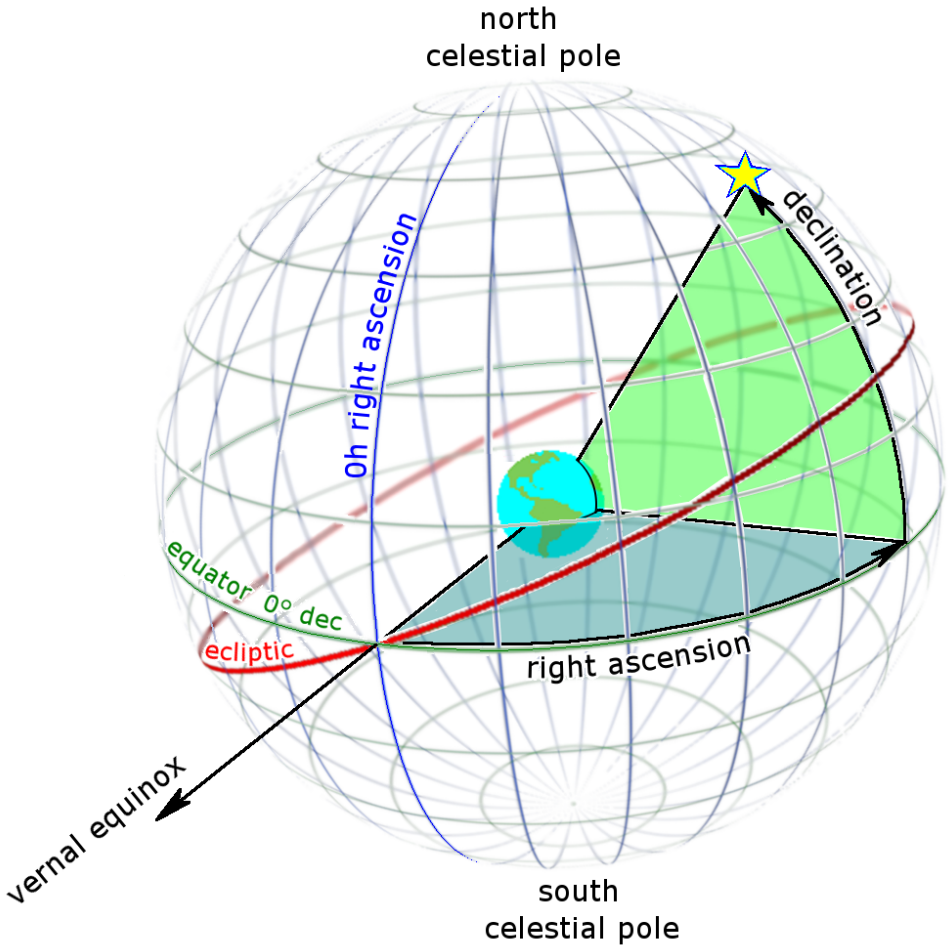
Coordinates (`astropy.coordinates`) -

- `Angle`, `SkyCoord`, `AltAz` classes for angular measures
- Methods: `transform_to`, `get_constellation`, `separation`, `separation_3d`
- `EarthLocation` class

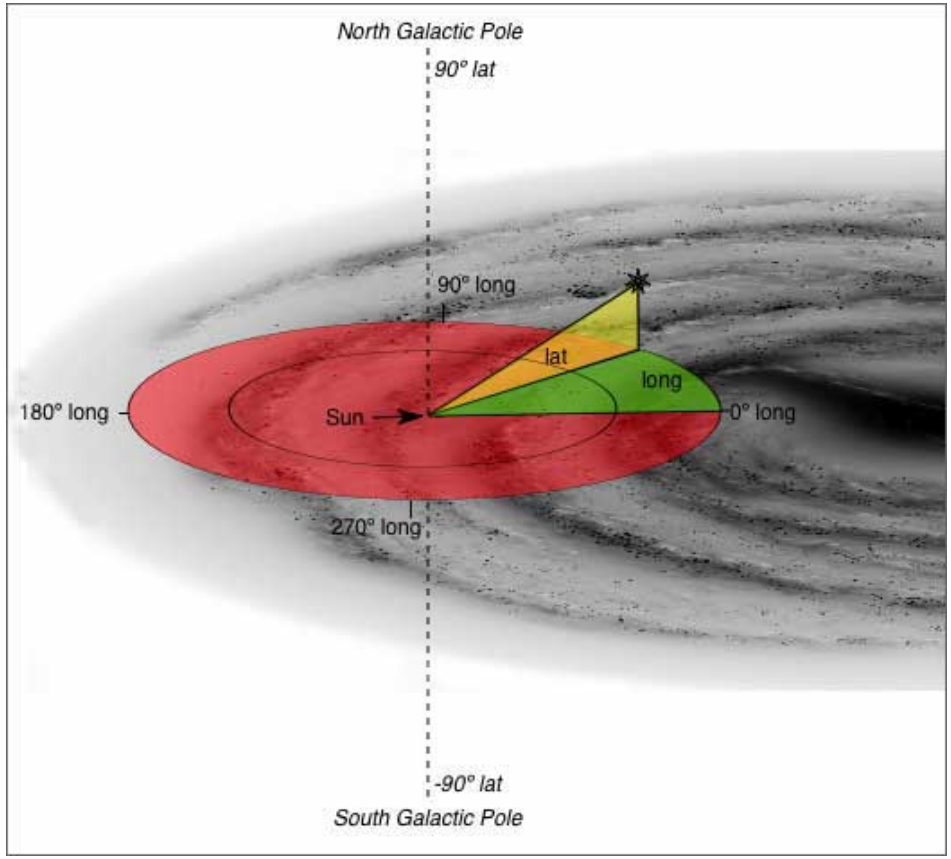
Times and dates (`astropy.time`) -

- `Time` class
- Current time – `Time.now()`
- Time scales – UTC, sidereal time
- Time formats – ISO, JD/MJD, datetime

Two important coordinate systems



Equatorial coordinates
Right ascension measured from location of the Sun on the sky on the vernal equinox; declination from equator

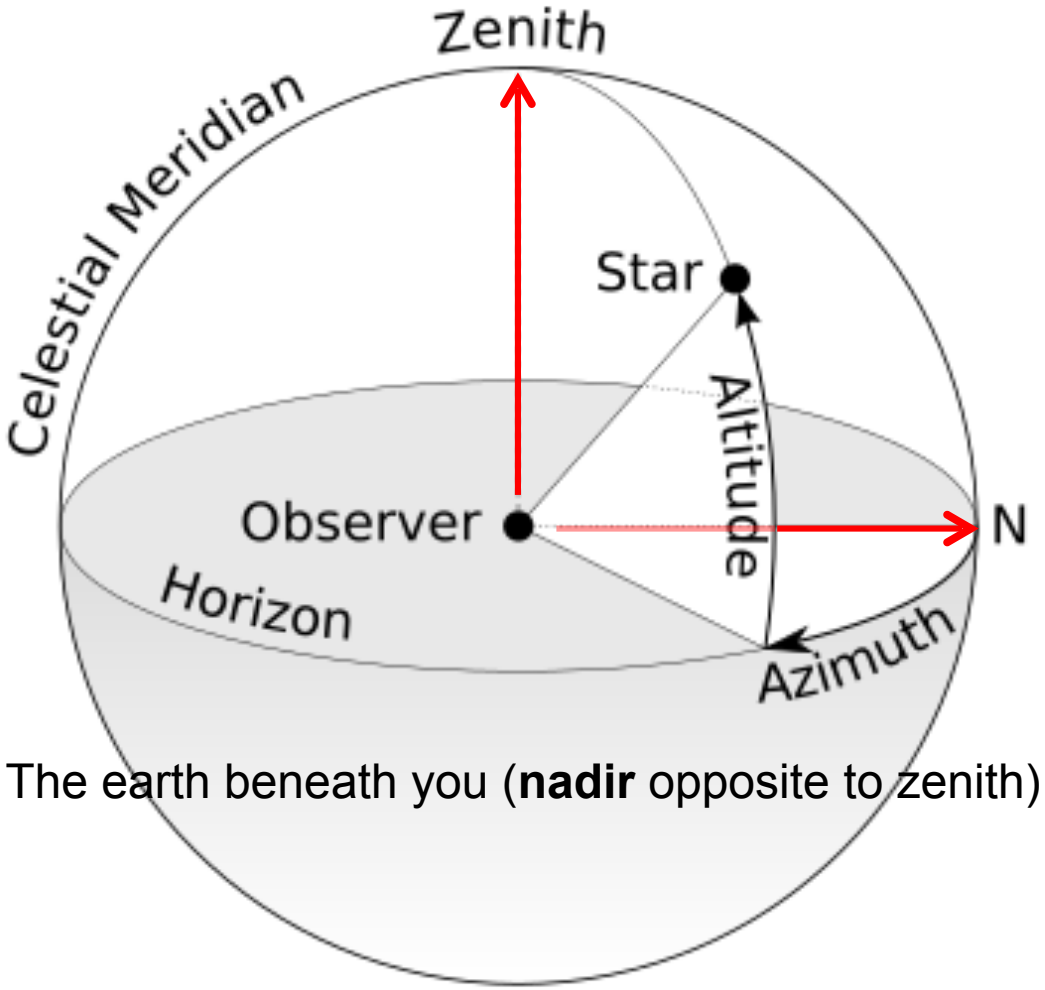


Galactic coordinates
Longitude measured from direction of Galactic center; latitude from Galactic plane

Wikipedia

Another important coordinate system

The directions relative to the stars in which the Zenith and North vectors point depend on your location on Earth's surface as well as the time and date.



Azimuth is measured from North towards East

Altitude-azimuth

(horizontal coordinates)

Wikipedia

Install astropy (if needed) & check version

Watch out for some version clashes that will create problems for you later in the semester.

```
$ python
Python 3.12.0 | packaged by conda-forge | (main, Oct  3 2023, 08:43:38) [Clang
15.0.7 ] on darwin
Type "help", "copyright", "credits" or "license" for more information.
>>> import astropy
>>> print(astropy.__version__)
5.3.4
>>> import matplotlib
>>> print(matplotlib.__version__)
3.8.2
>>>
```

Notes:

1. if "import astropy" doesn't work you will need to install astropy (see www.astropy.org)
2. You need astropy version 5.3 or higher. If you have 5.1, you will need to update (see same web page). Astropy 5.1.0 does not play nicely with matplotlib 5.7

Exercise 1: units and constants

Using Astropy, compute the following quantities.

Hints on how to get started are in the reading for today!

1. The escape velocity (in km/s) of a $2.3\,M_\odot$ giant star with a radius of $150\,R_\odot$.

$$v_{esc} = \sqrt{\frac{2GM}{R}}$$

2. The wavelength (in Angstroms) of the peak of the spectrum of a 11,350 K blackbody.

$$\lambda_{\text{peak}} = \frac{0.29\ \text{cm K}}{T}$$

3. The orbital period (in minutes) of a $1\,M_\odot$ white dwarf orbiting a $0.6\,M_\odot$ white dwarf at a separation of 10^5 km.

$$P = 2\pi\sqrt{\frac{a^3}{G(M_1 + M_2)}}$$

4. The Compton wavelength (in fm) of a nickel-56 nucleus, given its rest mass of 52.110 GeV/c^2.

$$\lambda = \frac{h}{mc}$$

5. The distance (in Mpc) to a radio galaxy with a flux density of 8400 Jy and a spectral luminosity of $6 \times 10^{35}\ \text{erg s}^{-1}\ \text{Hz}^{-1}$.

$$F_\nu = \frac{L_\nu}{4\pi d^2}$$

Exercise 2: sky coordinate conversions and angles

Using `SkyCoord`, `EarthLocation`, and `Time` objects, perform the following calculations:

- Find the angular distance between the Galactic center ($l = 0^o$, $b = 0^o$ in galactic coordinates) and the globular cluster M13.

- Find the angular distance between Venus and the Sun on February 29, 2024 at 23:00 UTC (ie. "2024-02-29T23:00:00"). Use the `astropy.coordinates.get_body()` method to get sky coordinates for Solar System bodies at a given time.

- Create an altitude-azimuth coordinate frame object (`AltAz`) corresponding to the location of the ALMA Observatory at the same time as above. Create a `SkyCoord` object corresponding to the sky position of the Large Magellanic Cloud (RA 05h23m34.5s, Dec –69d45m22s in the 'icrs' frame). Finally, using the `SkyCoord` object's `transform_to` method, find its representation in the alt-az frame you created. This will give the altitude and azimuth of the LMC at ALMA this evening at 8 pm local time.

Upload time!