# Preparation of astronomical observations

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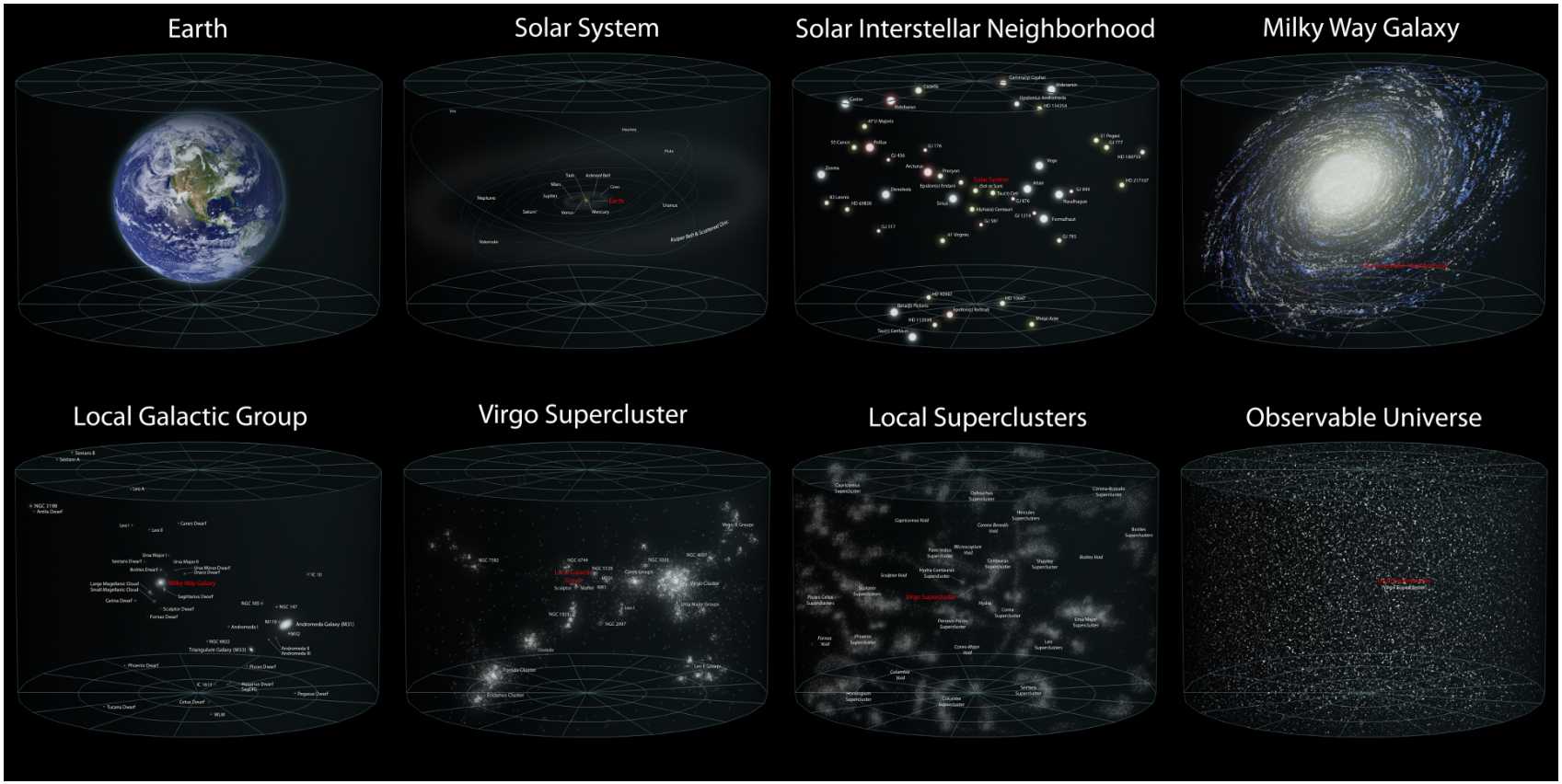
# The observable Universe

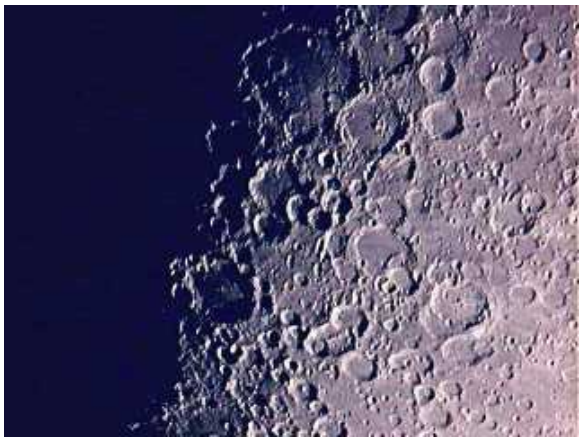


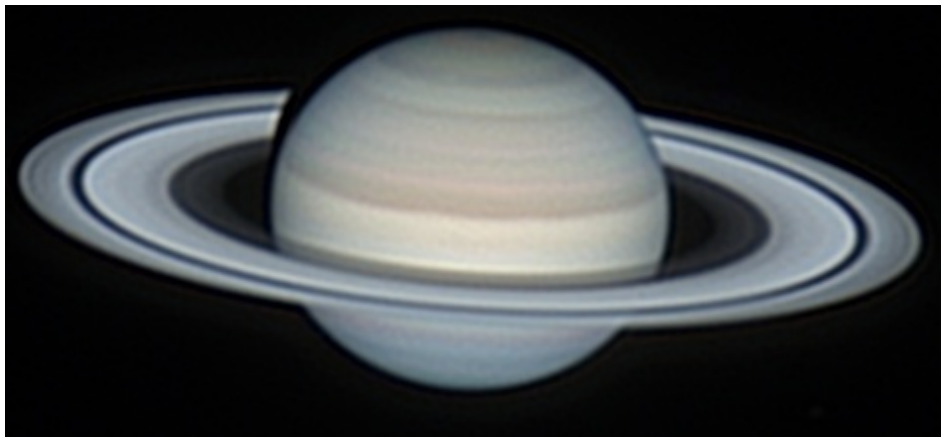
- Galaxies
  - can be observed in almost all parts of the sky;
    - except where the Milky Way obstructs the view.
  - Usually very low surface brightness;
    - Need for a dark sky and no moon.

- Large clouds of gas and dust within our Galaxy;
- Low contrast and surface brightness;
- Easiest ones to observe are found in *Messier*'s catalog.

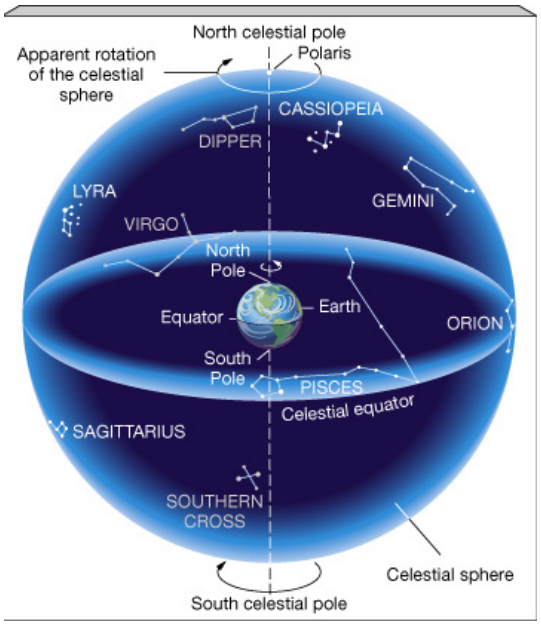
- Appear as point-like objects;
- Very good contrast, good brightness;
- Good targets for spectroscopy.

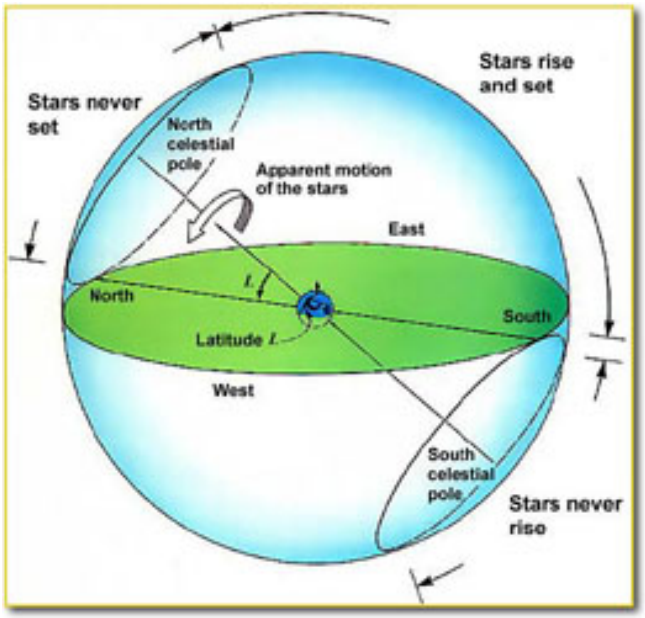
- Move against the background stars: trickier to find;
- Large diversity of objects;
  - Moon;
  - Planets;
  - Asteroids;
  - Comets.



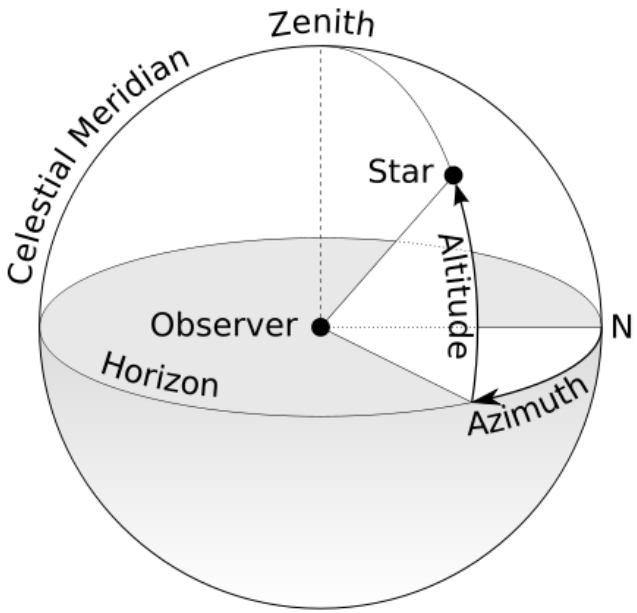


- Celestial objects (out of our own solar system) are so far away that their **direction** with respect to the center of Earth always stays the same.
- These directions can be recorded on the celestial sphere.
- Distance information lost ⇒ only two coordinates needed.
- An observer on the ground can only see **half** of the celestial sphere at any given time.

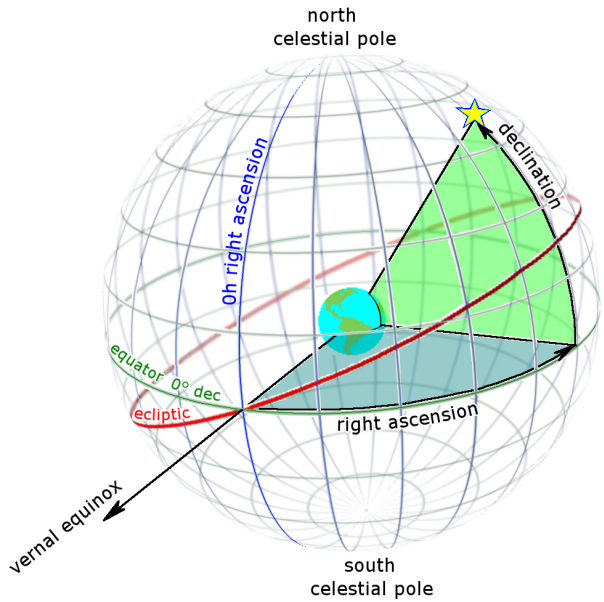


- Most naive system possible
  - Azimuth $0^\circ$ to $360^\circ$. Heading to the object
    $0^\circ$ = North; $90^\circ$ = East; etc.
  - Altitude $0^\circ$ (horizon) to $90^\circ$ (zenith). Negative values located below the horizon.
- Not very useful in astronomy due to apparent motion of the sky, except for observational limitations in altitude.



- Right ascension (RA)
  - From $0$ to $24^h$, $1^h$ subdivided into $60^m$ and $3600^s$
  - Analogous to longitude
  - Arbitrary reference (vernal point $\gamma$)
- Declination (Dec)
  - From $-90^\circ$ to $+90^\circ$, $1^\circ$ subdivided into $60'$ and $3600''$.
  - Analogous to latitude.
  - **Caution!** $15^\circ \equiv 1^h \Rightarrow 15' \equiv 1^m; 15'' \equiv 1^s$



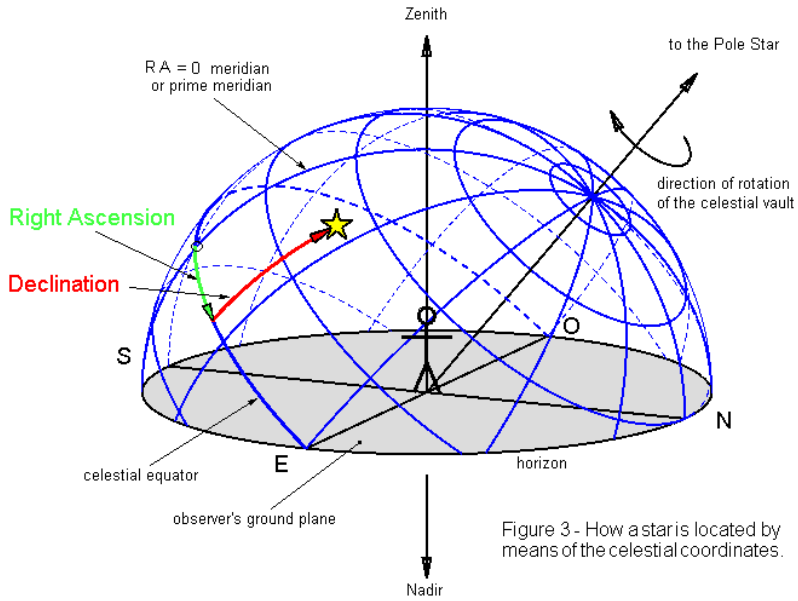
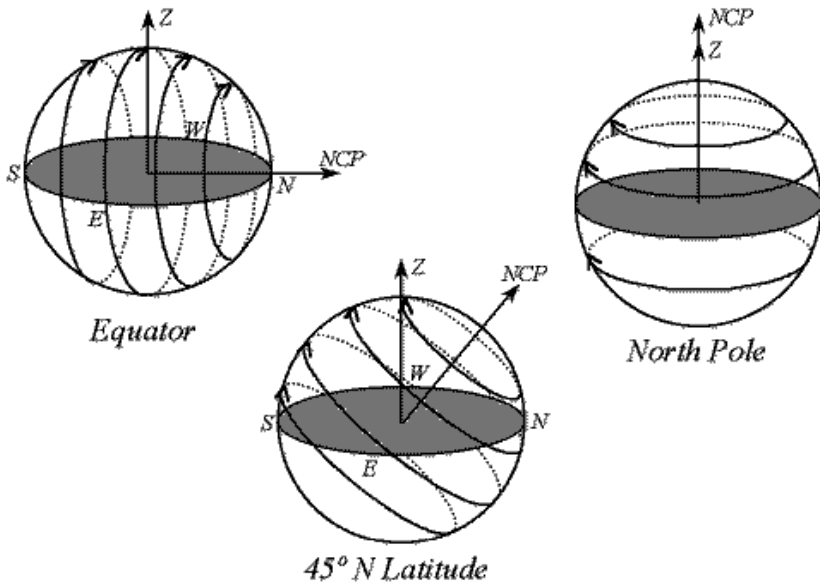
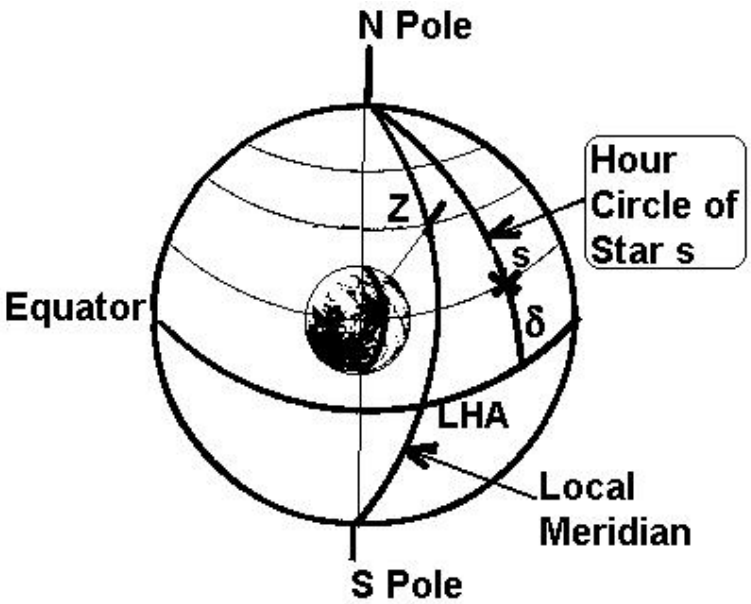



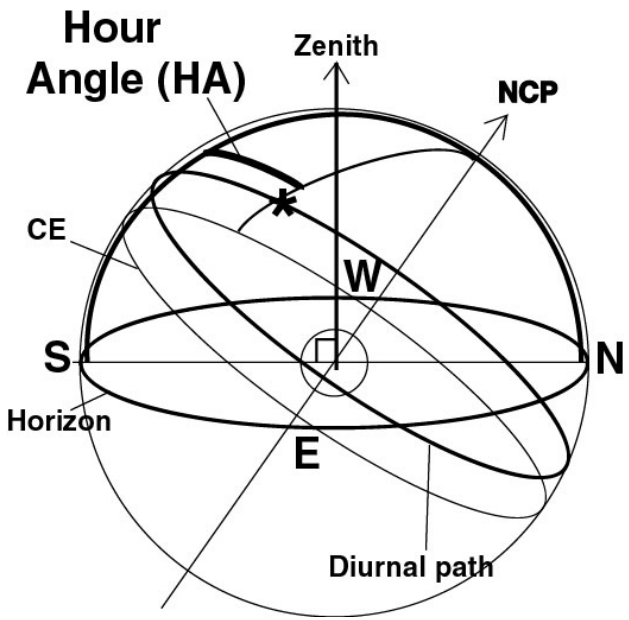

Figure 3 - How a star is located by means of the celestial coordinates.

- The Earth rotates in $23\,\mathrm{h}\ 56\,\mathrm{min}\ 4\,\mathrm{s}$ with respect to the celestial sphere (sidereal day).
- Results in the **apparent motion** of the celestial grid around the north celestial pole.

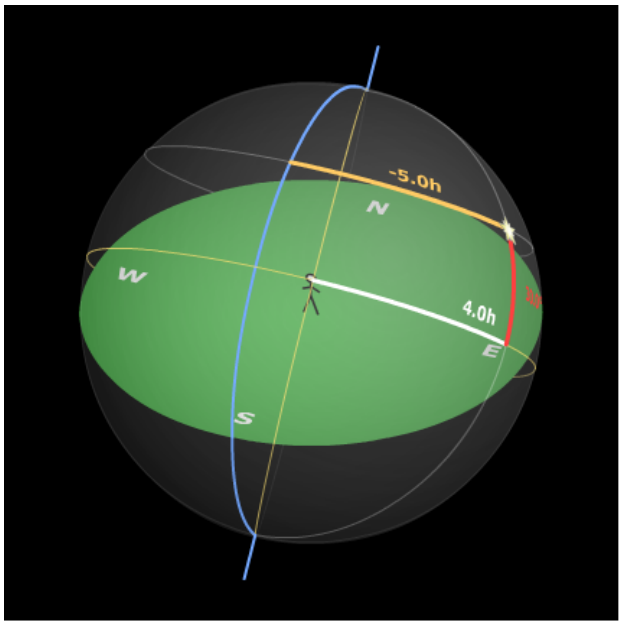


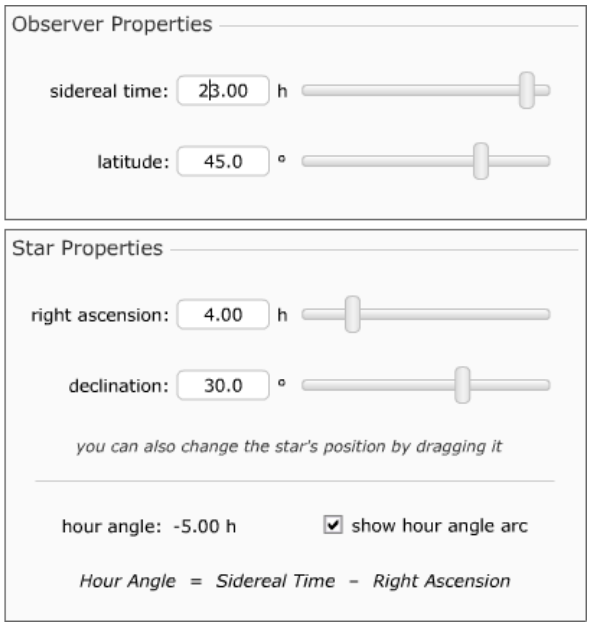
- **Fixed** with respect to the **observer**.
- Set to $0^h$ along the meridian direction (where celestial objects culminate)
- (HA,Dec) is the preferred coordinate system for **equatorial mounted** telescopes.

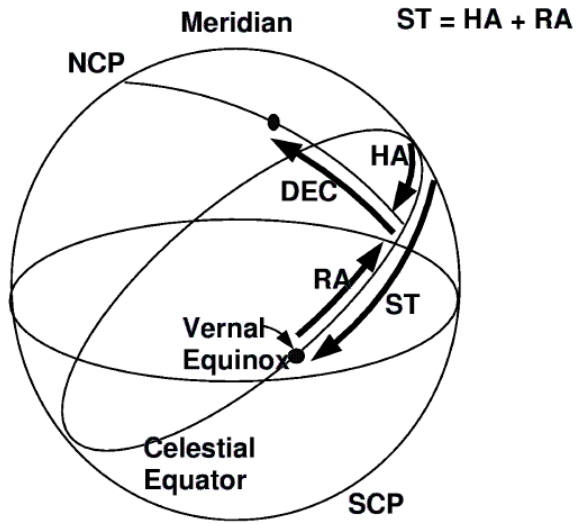


- RA and HA gradually drift apart as Earth rotates inside the celestial sphere.
- This drift is measured by the Sidereal Time (actually, an angle) : $HA = ST - RA$
- ST drifts with **time** and varies with **longitude**
  - $24^h$ per **sidereal** day ($= 23\,\mathrm{h}\,56\,\mathrm{min}\,4\,\mathrm{s}$).



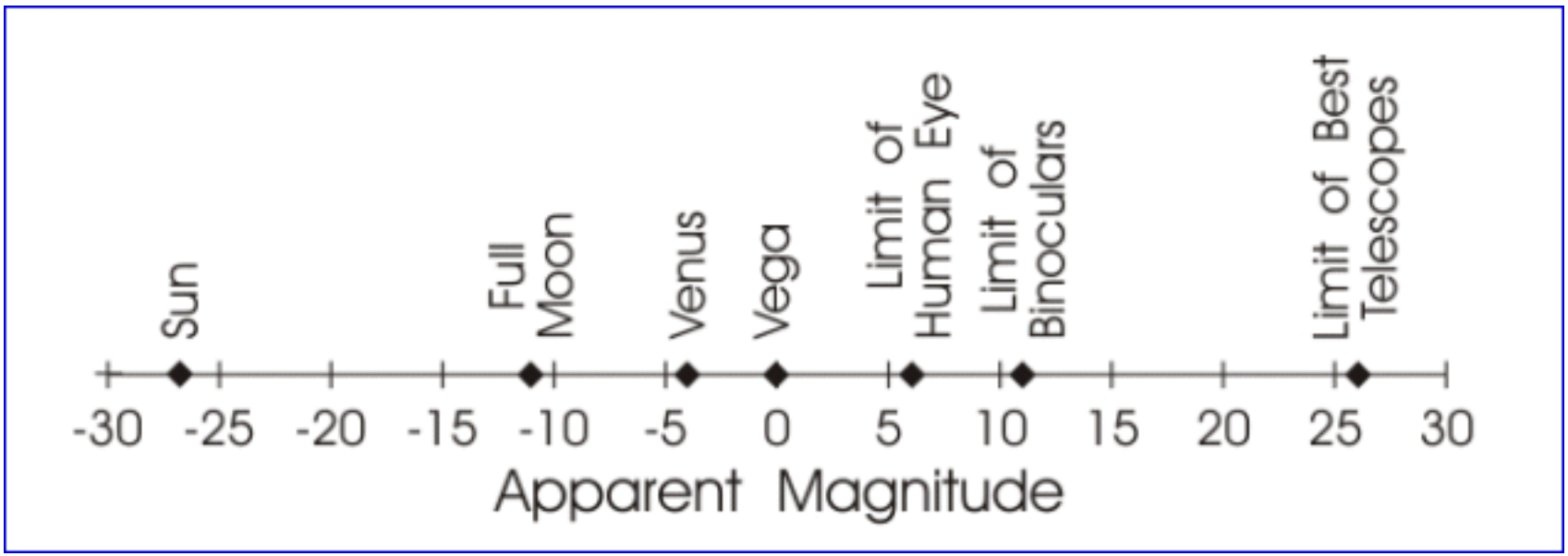



**Origin** Devised during Antiquity to rank stars.
From 1st class (brightest) to 6th class (faintest).

**Definition** $M = -2.5 \log_{10}(F/F_0)$

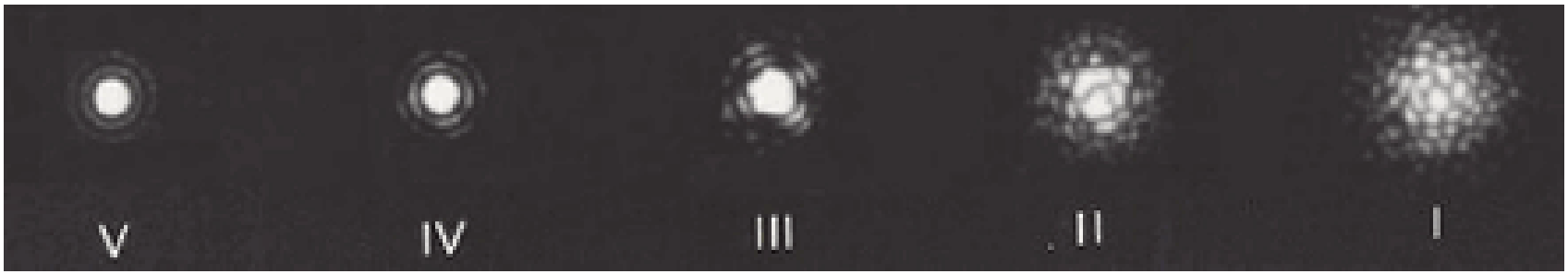
- where $F$ is the received flux within a waveband;
- and $F_0$ a reference (originally Vega's) flux in the same waveband.

**Point-like sources** Lower magnitude $\Rightarrow$ better contrast.



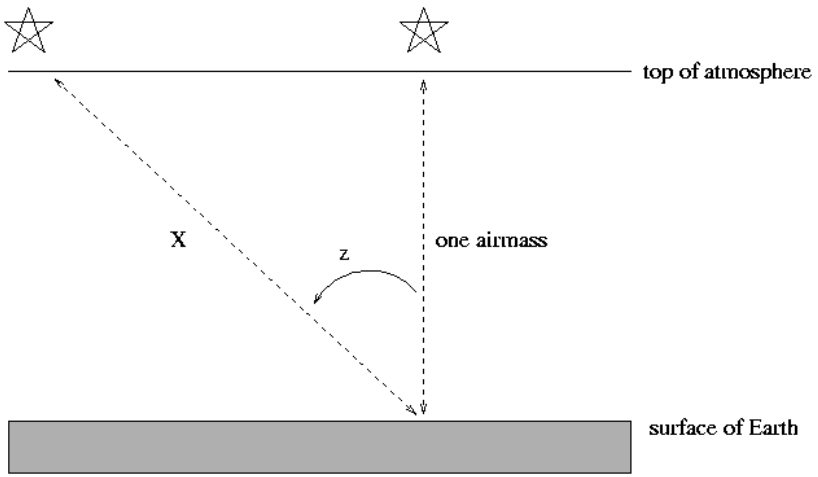
- Relevant quantity: magnitude per solid angle
  - Black sky brightness (OHP): $20.7\,\mathrm{mag}/''^2$
  - $1''^2 \simeq 2.35 \cdot 10^{-11}\,\mathrm{sr}$
- Pay attention to the angular size of the object compared to the field of view (FoV).
  - $0.8\,\mathrm{m}$ telescope (OHP): $15'$
  - Andromeda galaxy (M31) spans a few degrees, so larger than FoV.

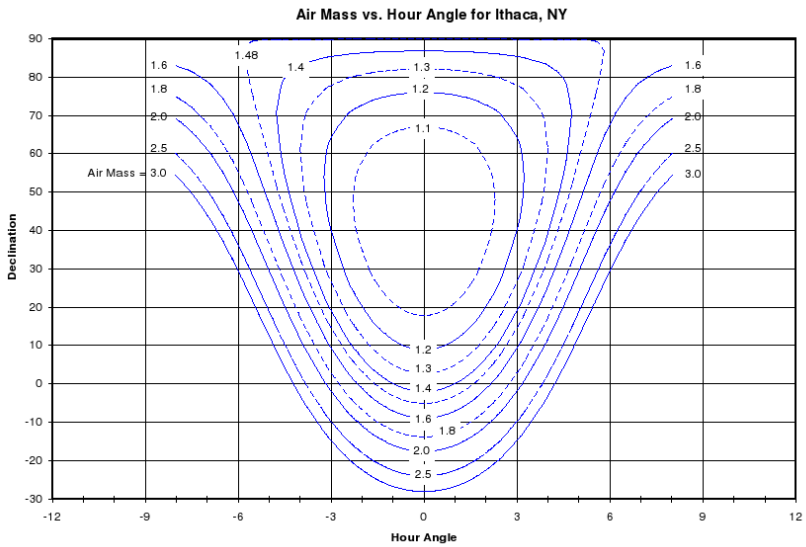
- Origin Atmospheric turbulence distorts light rays incoming from outer space, resulting in a blur.
- Typical extent: $1$ to $2''$
- Limits the spatial resolution of the instrument.




*Good seeing* $\longrightarrow$ *Bad seeing*

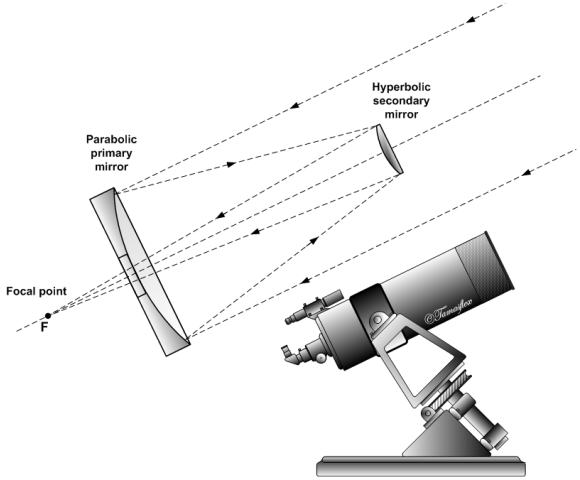
- Definition Slant optical depth $\tau$ of an incoming ray wrt. minimal optical depth at zenith $\tau_0$ : $X = \tau/\tau_0 \geqslant 1$
- Far from the horizon (plane-parallel assumption), we have $X \simeq 1/\cos z$
- Smaller airmass $\Rightarrow$ less absorption, better seeing.



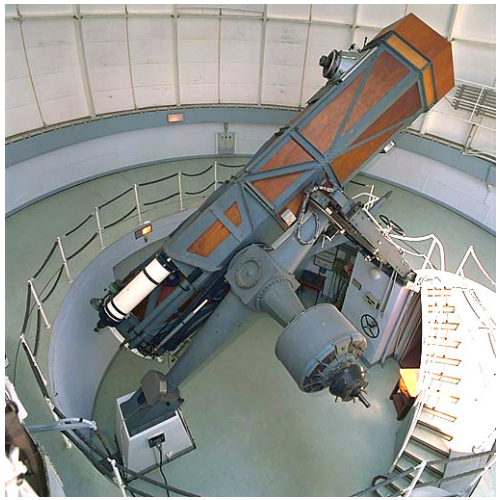



- Nightglow from excited $O_2$ molecules;
- Also light pollution from artificial lighting;
- Mainly in the near IR, also in the visible (green).

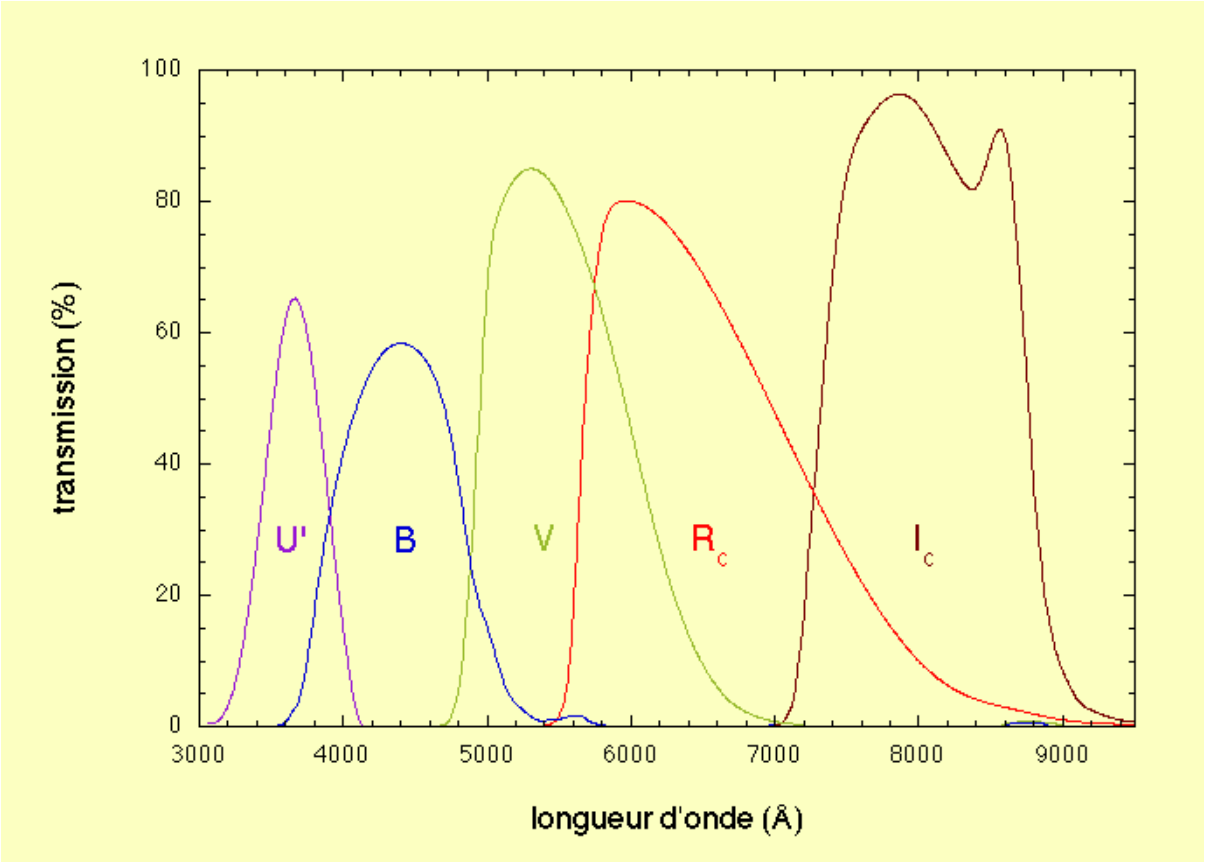
- Manual tracking
  - but motor to compensate sidereal time
- Visual observations
  - Several eyepieces available
- Imaging observations
  - CCD camera and data reduction software installed
- Spectroscopic observations
  - At OHP, only with the 1.93 m, 1.52 m and 1.20 m telescopes.




- Availability
  - For **planetary science** and **astronomy** SIMO students.
  - Operating under the supervision of an expert operator!
- Observations
  - Imaging observations (with RGB filters)
  - Visible range **spectroscopy** ($400 - 700$ nm, $R \sim 1000$)



- Necessary for imaging mode
- Broadband and narrowband filters (e.g. H$\alpha$) available




*Spectral transmissions for the older filter set on the* $0.8$ *m telescope*

1. Night's conditions
   - Getting sunset and sunrise times
   - Meeting the person in charge of the telescope
   - Gather technical info: blind zones, FOV, filters or gratings, camera specs
   - Checking sidereal time
   - Moon phase and location, rising and setting times
   - Weather

2. Choice of objects
   - Checking ephemerides on the Internet
   - Checking visibility of object: brightness, location
   - Back-up objects in order of priority

# Ephemerides

- **Online**

  IMCCE website (solar system)

  `http://www.imcce.fr/`

  SIMBAD database

  `http://simbad.u-strasbg.fr/simbad/sim-fbasic`

- **Offline**

  Celestia `https://celestiaproject.space/`

  Stellarium `http://www.stellarium.org`

# Image Processing

ImageJ `https://imagej.nih.gov/ij/download.html`

AstroImageJ `http://www.astro.louisville.edu/software/astroimagej/`

GIMP `https://www.gimp.org/downloads/`

Registax `http://www.astronomie.be/registax/`

## Includes at least the following columns

- Time (local, universal, sidereal);
- Name of object to observe at that time;
- Type of object;
- Coordinates in equatorial system (RA, Dec) ($1'$ accuracy);
- Coordinates in local system (HA, Dec) ($1'$ accuracy);
- Altitude above horizon;
- Chosen filter or grating;
- Magnitude in the relevant waveband.

- T80 absolute pointing imprecise to a few arcmins;

$\Rightarrow$ Necessity of taking a short exposure frame to check the pointing

- If the object is too faint to be seen in a short exposure frame, a finding chart is necessary
  - = Schematic diagram of the neighboring bright sky objects obtained by e.g. SIMBAD
- Other technical observations
  - Focusing observations (also yield seeing estimates)
  - Calibration: flat fields, dark fields and offsets.

## Previous SIMO editions – M2 Planetary Science Students