Observational Astronomy - Lecture 2
Constellations, Magnitudes, Types of Objects, Locating Objects

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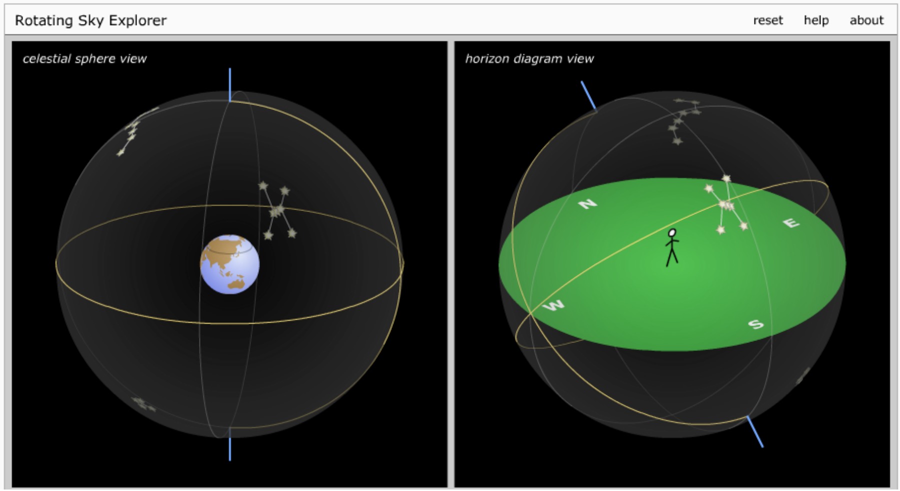
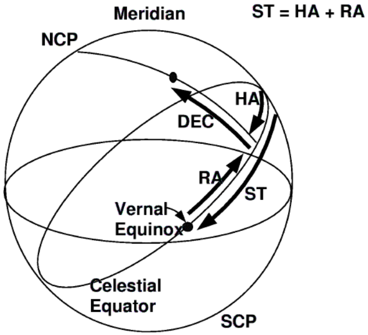
Animation of Celestial Sphere

http://astro.unl.edu/naap/motion2/animations/ce_hc.html



Sidereal Time and Hour Angle



- Objects currently transiting have a right ascension equal to your local sidereal time.
- Objects currently transiting have Hour Angle = 0.
- Objects east of the meridian have a negative hour angle.
- Objects west of the meridian have a positive hour angle.

Hour Angle = Local Sidereal Time - Right Ascension

Estimating Transit Times - Key Ideas

- The Sun transits at local noon (that's what noon is).
- The Sun is at RA = 0h on the vernal equinox (about Mar 21).
- Other times are given in the table below.
- A given RA transits about 4 minutes earlier each night.

Date	Transits at Noon	Transits at Midnight
Mar 21	$\mathrm{RA} = 0^{\mathrm{h}}$	$\mathrm{RA} = 12^{\mathrm{h}}$
Jun 21	$\mathrm{RA} = 6^{\mathrm{h}}$	$\mathrm{RA} = 18^{\mathrm{h}}$
Sep 21	$\mathrm{RA} = 12^{\mathrm{h}}$	$\mathrm{RA} = 0^{\mathrm{h}}$
Dec 21	$\mathrm{RA} = 18^{\mathrm{h}}$	$\mathrm{RA} = 6^{\mathrm{h}}$

Estimating Transit Times: Example 1

When will Rigel transit on Feb 3?

- Rigel - $\mathrm{RA} = 5^{\mathrm{h}}14^{\mathrm{m}}$
- $\mathrm{RA} = 6^{\mathrm{h}}$ transits at midnight on Dec 21.
- Number of days between Dec 21 and Feb 3 = 10 + 31 + 3 = 44.
- Transit time shift at 4 min/day = 4 * 44 = 176 min = $2^{\mathrm{h}}56^{\mathrm{m}}$.
- On Feb 3, $\mathrm{RA} = 6^{\mathrm{h}}$ transits at $24^{\mathrm{h}} - (2^{\mathrm{h}}56^{\mathrm{m}})$ = 21:04 = 9:04 PM.
- $\mathrm{RA} = 5^{\mathrm{h}}14^{\mathrm{m}}$ transits at $21^{\mathrm{h}}04^{\mathrm{m}} - 46^{\mathrm{m}} = 20^{\mathrm{h}}18^{\mathrm{m}}$ = 8:18 PM.
- Stellarium gives 8:14 PM.
- These calculations will only be with $\approx 10^{\mathrm{m}}$ or so due to:
  - We are not at the center of the time zone.
  - 4 min/day is a little off (actually $3^{\mathrm{m}}56^{\mathrm{s}}$).

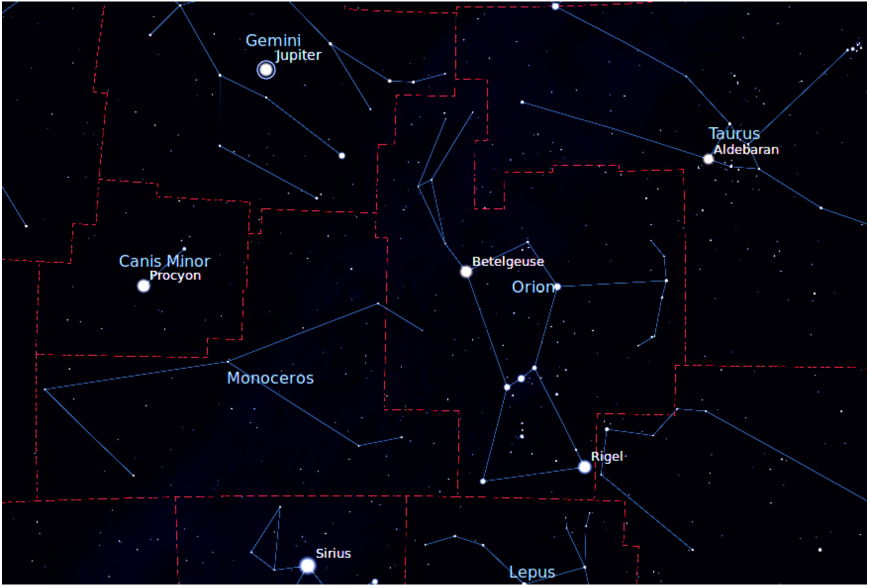
Estimating Transit Times: Example 2

When will Saturn transit on May 1, 2014?

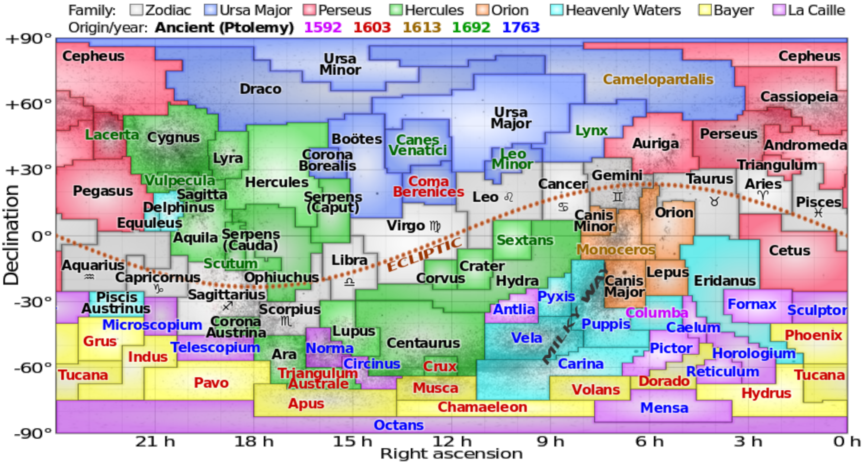
- On this date Saturn - $\mathrm{RA} = 15^{\mathrm{h}}15^{\mathrm{m}}$ (look this up).
- $\mathrm{RA} = 18^{\mathrm{h}}$ transits at midnight on Jun 21.
- Number of days between Jun 21 and May 3 = 21 + 30 = 51.
- Transit time shift at 4 min/day = 4 * 51 = 204 min = $3^{\mathrm{h}}24^{\mathrm{m}}$.
- On May 1, $\mathrm{RA} = 18^{\mathrm{h}}$ transits at $24^{\mathrm{h}} + (3^{\mathrm{h}}24^{\mathrm{m}})$ = 3:24 AM.
- $\mathrm{RA} = 15^{\mathrm{h}}15^{\mathrm{m}}$ transits at $3^{\mathrm{h}}24^{\mathrm{m}} - 2^{\mathrm{h}}45^{\mathrm{m}} = 0^{\mathrm{h}}39^{\mathrm{m}}$ = 12:39 AM.
- Add one hour for Daylight Savings Time = 1:39 AM.
- Stellarium gives 1:31 AM.

Constellation Orion - Basic View

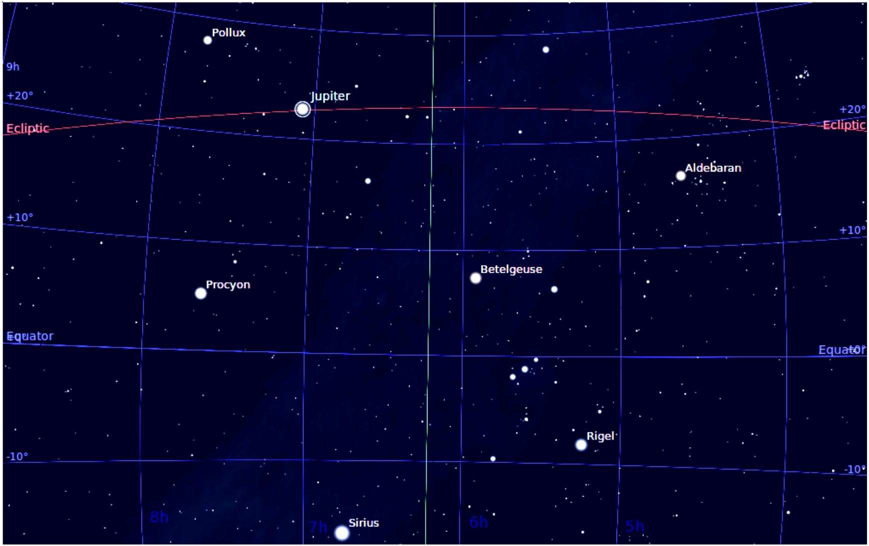
Constellation Boundaries - Stellarium



Constellation Map - 88 Constellations cover the sky



Equatorial Coordinates - Stellarium



Magnitudes - brightness of objects

- Hipparchus defined the original magnitude scale:
  - Brightest stars - Magnitude 1
  - Dimmest stars - Magnitude 6
- Much later, measurements revealed $\approx 100\mathrm{X}$ difference between these two.
- Our senses respond logarithmically.
- Accordingly, magnitude is defined as follows (here I is the *intensity* of the object):

$$\mathrm{m}_{\mathrm{object}} - \mathrm{m}_{\mathrm{reference}} = -2.5 \ \ \log_{10}(\frac{\mathrm{I}_{\mathrm{object}}}{\mathrm{I}_{\mathrm{reference}}})$$

- This means that each smaller magnitude is $10^{0.4} = 2.512$ times brighter than the one before.

Typical Magnitudes

Remember - brighter objects have smaller magnitudes!

- Sun ≈ -27
- Full Moon ≈ -13
- Venus ≈ -4
- Jupiter ≈ -2.5
- Sirius (brightest star) ≈ -1.5
- Vega (historical standard) ≈ 0
- Faintest star visible with naked eye (Manhattan) ≈ 3.5
- Faintest star visible with naked eye (dark skies) ≈ 6.0
- Faintest star visible with binoculars (dark skies) ≈ 9.5
- Faintest star visible with Hubble space telescope ≈ 31.5

Absolute and Apparent Magnitudes - 1

- Apparent magnitudes tell how bright an object appears.
- Absolute magnitudes tell how intrinsically bright an object is.
  - An object can appear bright because it is intrinsically bright, or simply because it is close.
  - Absolute magnitude is defined as the apparent magnitude when viewed at a distance of 10 parsecs.
    - We will discuss parsecs later.
    - For now, it is a distance equal to about 3.2 light-years.
  - The sun has an ~~apparent~~ magnitude of 4.83.
  - Astronomers usually use m for apparent magnitudes, M for absolute magnitudes.

Absolute and Apparent Magnitudes - 2

- Recall:

$$m_{obj} - m_{ref} = -2.5 \ \log_{10}(\frac{I_{obj}}{I_{ref}}) = 2.5(\log_{10}(I_{ref}) - \log_{10}(I_{obj}))$$

- As objects get further away, they get fainter according to the inverse square law.
- Here I is the *intensity* of the light received, L is the *luminosity* of the object, and D is the distance in parsecs.

$$I(D) = \frac{L}{4\pi D^2}$$

- Taking logs of both sides:

$$\log_{10}(I(D)) = \log_{10}(L) - 2\log_{10}(D) - \log_{10}(4\pi)$$

Absolute and Apparent Magnitudes - 3

- So:

$$\mathrm{m(D)} - \mathrm{m(10)} = 2.5(\log_{10}(\mathrm{L}) - 2\log_{10}(10) - \log_{10}(4\pi) - (\log_{10}(L) - 2\log_{10}(D) - \log_{10}(4\pi))$$

$$\mathrm{m(D)} - \mathrm{M} = 2.5(-2 + 2\log_{10}(\mathrm{D}))$$

$$\mathrm{m(D)} = \mathrm{M} - 5 + 5\log_{10}(\mathrm{D})$$

- We can also write:

$$\mathrm{M_{obj}} - \mathrm{M_{ref}} = -2.5 \;\; \log_{10}(\frac{\mathrm{I_{obj}}}{\mathrm{I_{ref}}}) = -2.5 \;\; \log_{10}(\frac{\mathrm{L_{obj}}}{\mathrm{L_{ref}}})$$

$$\frac{\mathrm{L_{obj}}}{\mathrm{L_{ref}}} = 10^{0.4(\mathrm{M_{ref}} - \mathrm{M_{obj}})}$$

Magnitude Example

Polaris is 132 pc away and has apparent magnitude +1.95. What is its absolute magnitude, and how much brighter than the sun is it?

- m = +1.95, D = 132 pc
- $\mathrm{m} = \mathrm{M} - 5 + 5\log_{10}(\mathrm{D})$
- $\mathrm{M} = \mathrm{m} + 5 - 5\log_{10}(\mathrm{D})$
- $\mathrm{M} = 1.95 + 5 - 5\log_{10}(132) = -3.65$

$$\frac{\mathrm{L_{Polaris}}}{\mathrm{L_{Sun}}} = 10^{0.4(\mathrm{M_{Sun}} - \mathrm{M_{Polaris}})}$$

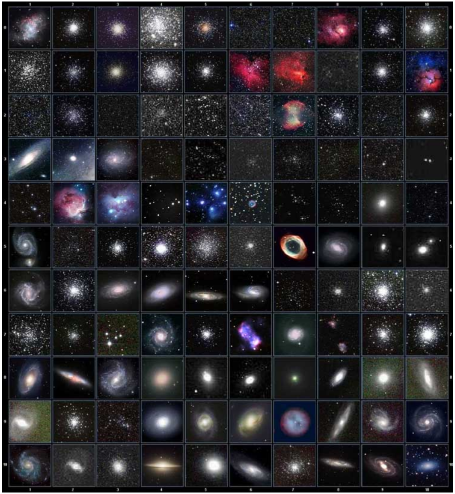
$$\frac{\mathrm{L_{Polaris}}}{\mathrm{L_{Sun}}} = 10^{0.4(4.83-(-3.65))} = 10^{3.39} = 2466$$

Types of Objects

Most interesting objects fall into these categories:

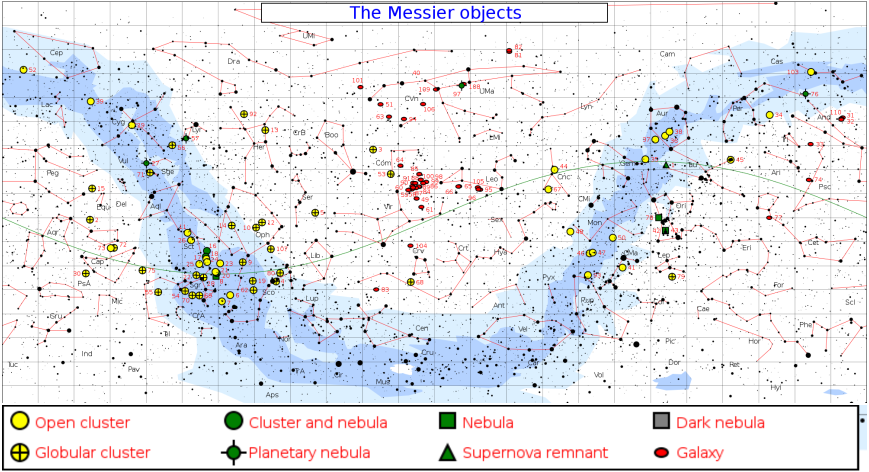
- Sun
- Moon
- Planets
- Stars
- Globular clusters
- Open clusters
- Nebulae
- Galaxies

Types of Objects - Messier Objects



- List compiled by Charles Messier to avoid confusion with comets.
- Some of the most interesting objects in the sky.
- List runs from M1 to M110

Types of Objects - Messier Objects



Globular Clusters

Large, spherical clusters containing millions of stars which orbit our galaxy.

M13 - Globular Cluster in Hercules

M10 - Globular Cluster in Ophiuchus

Open Clusters

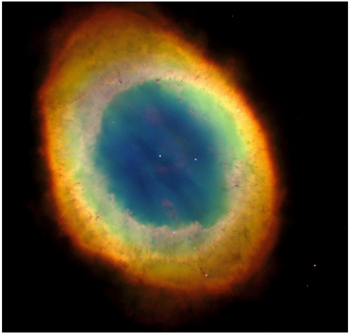
Smaller, clusters of young stars within our galaxy.

M45 - Open Cluster in Taurus - Also called The Pleiades, The Seven Sisters, or Subaru.

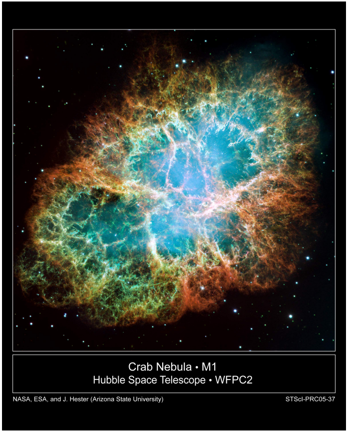
M44 - Open Cluster in Cancer The Beehive

Nebulae

Large clouds of gas heated to incandescence by stars embedded in them.



M57 - Planetary Nebula in Lyra

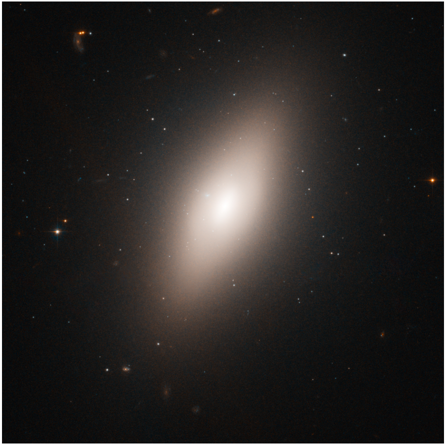


M1 - Supernova remnant in Taurus. This supernova exploded in 1054 AD, and was visible in the daytime..

Galaxies

Large collections of billions of stars. Our galaxy is called the Milky Way.

Spiral galaxy - M51
The Whirlpool

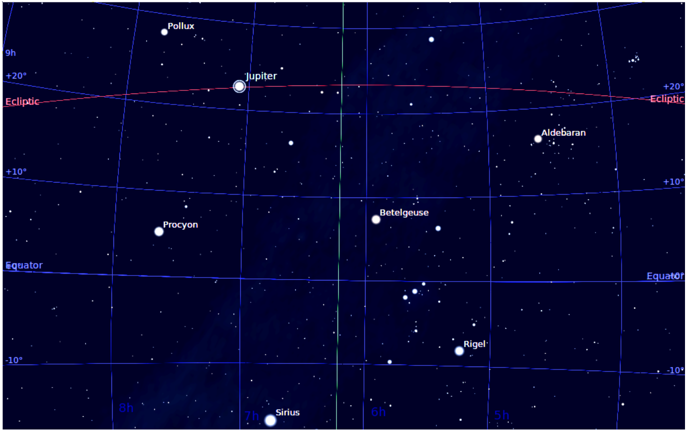


Elliptical galaxy

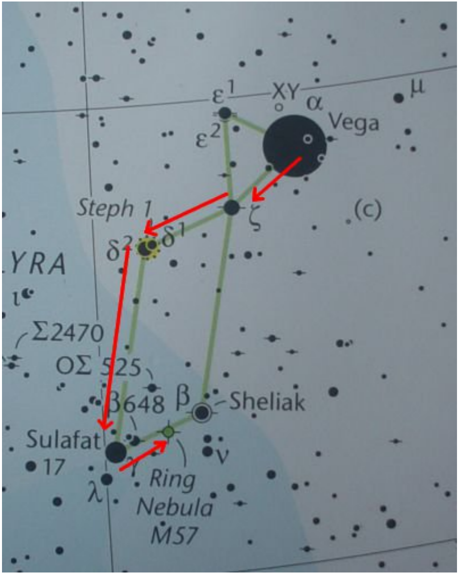
Locating Objects Using Coordinates

If your telescope is well calibrated (usually *NOT* the case!), you can locate objects using coordinates:

Rigel - RA $= 5^{\mathrm{h}}14^{\mathrm{m}}$, Dec $= -8^{\circ}12'$



Locating Objects Using “Star-Hopping”



Summary

1. We can calculate transit times by remembering a few key rules.
   - The Sun transits at local noon.
   - The Sun is at RA $=$ 0h on the vernal equinox (about Mar 21).
   - A given RA transits about 4 minutes earlier each night.
2. The sky is divided into 88 constellations.
3. Magnitudes are used to specify the brightness of objects. Larger magnitudes are fainter.
   - Absolute magnitudes give the actual brightness.
   - Apparent magnitudes tell how bright the object appears.
4. There are many different types of objects in the sky.
5. We can find objects with coordinates, or by their relation to other objects.