

Observational Astronomy - Lecture 1

Introduction, Distances and Angles, Coordinates

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- Web site: cosmo.nyu.edu/lage/obs_astro
 - Syllabus
 - Lectures
 - Labs
 - Homework
 - Support Material

Logistics

- Lecture - 3:30pm Monday in Meyer 102
- Lab M or W 6:20pm in Meyer 224
 - Arrive on time!
 - We will meet in Meyer 224, then decide whether the lab is indoors or outdoors based on the weather.
 - You cannot change labs because they get out of synch - you must stay with the M or W lab.
 - Outdoor labs on top of 1 Washington Place.
 - It's cold up there - dress warmly!
 - Let me repeat - you will be standing still for 2+ hours - dress really warmly!
- Homework
 - For each lecture, there is a sheet of homework questions to answer.
 - These are due at the beginning of the next lecture.
- Grading
 - Labs - 25%
 - Homeworks - 15%
 - Midterm - 25%
 - Final - 35%

Astronomy - An Ancient Study



Chinese star chart
ca 4th Century BC



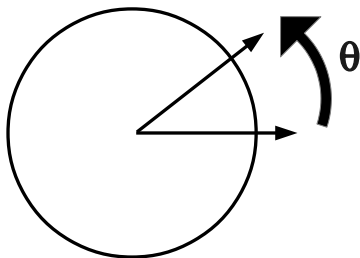
Hipparchus
Star catalog
129 BC

- Astronomy has been studied since ancient times.
- There has been a steady growth of our knowledge, which continues at a rapid pace today.

Constellation Orion

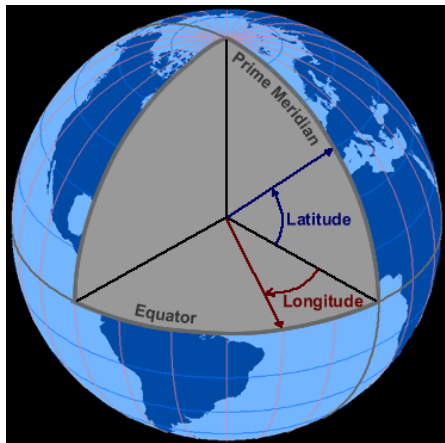


Angle Basics



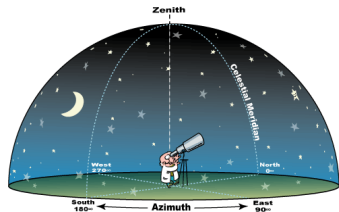
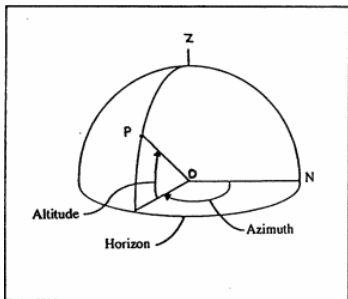
- Full Circle = 360 degrees = $360^\circ = 2\pi$ radians
- $1^\circ = 60$ minutes of arc = $60'$
- 1 minute of arc = 60 seconds of arc = $60''$
- $31^\circ 12' 32''$ - sexagesimal notation
- 31.37° - decimal notation

Latitude and Longitude



- Two angles are required to denote a direction in space.
- On Earth, we use latitude and longitude measured from the center of the Earth
- Equator - latitude = 0°
North Pole - latitude = $+90^\circ$
South Pole - latitude = -90°
- Need to specify a reference point for longitude - Prime Meridian through Greenwich Observatory, London

Stellar Coordinates - Altazimuth



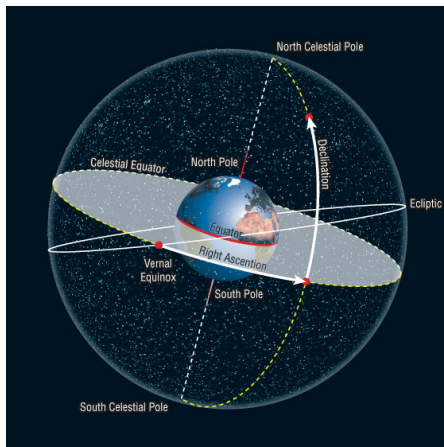
- The angle above the horizon is called the *altitude*
- The angle measured from North is called the *azimuth*
- The line on the sky from due North to due South is called the *meridian*
- An object crossing the meridian is said to be *transiting*
- The point straight up (altitude = 90°) is called the *zenith*
- The point straight down (altitude = -90°) is called the *nadir*

Problems with Altazimuth Coordinates



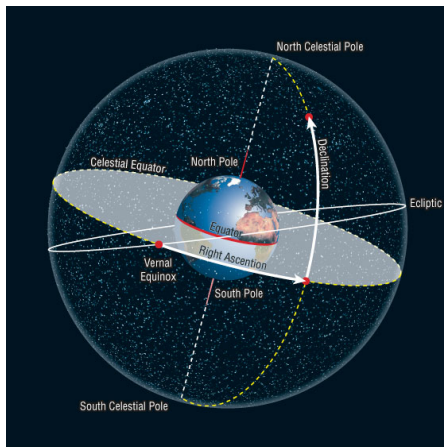
- There are two main problems with altazimuth coordinates:
- First, the coordinates of an object will be different for different observers at different points on Earth.
- Second, the stars move! So the alt-az coordinates will change even for a fixed observer.
- We need a set of coordinates that identify an object, which are the same for each observer and don't change with time.
- For this, we use *equatorial coordinates*

Stellar Coordinates - Equatorial 1



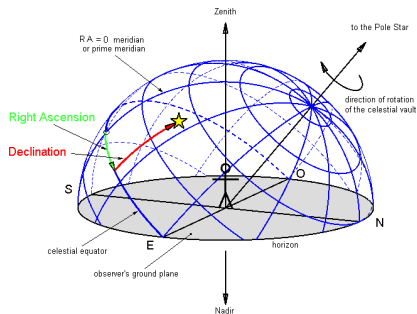
- Equatorial coordinates are obtained by projecting latitude and longitude onto the sky.
- The projection of the equator is called the *celestial equator*.
- The angle measured from the celestial equator (corresponding to latitude) is called *declination*.
- The point above the north pole (declination = $+90^\circ$) is called the *north celestial pole*.
- The point above the south pole (declination = -90°) is called the *south celestial pole*.

Stellar Coordinates - Equatorial 2



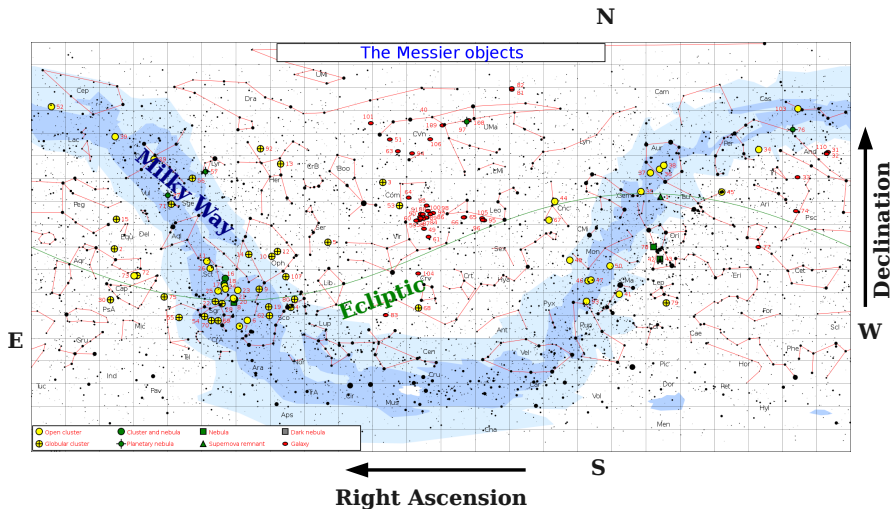
- The angle corresponding to longitude is called *right ascension*.
- The zero point of right ascension is the sun's location as it crosses the equator on the first day of spring, called the *vernal equinox*.
- The sun's path across the sky is called the *ecliptic*. This is also the plane of the Earth's orbit on the sky.
- The Earth's axis is tilted by 23.5° with respect to the plane of the Earth's orbit. This is what causes the seasons.

Stellar Coordinates - Equatorial 3



- While standing on the Earth, the stars seem to rotate about the celestial pole.
- We see only 1/2 of the sky at any given time.
- We can only see as far south as $\text{Dec} = -90^\circ + \text{Latitude}$.

Stellar Coordinates - A Star Chart



Star Charts have East on the left - We are looking up!

Specifying Stellar Coordinates

Right ascension typically specified using time:

3 hours, 24 minutes, 13 seconds is written as: $3^{\text{h}}24^{\text{m}}13^{\text{s}}$

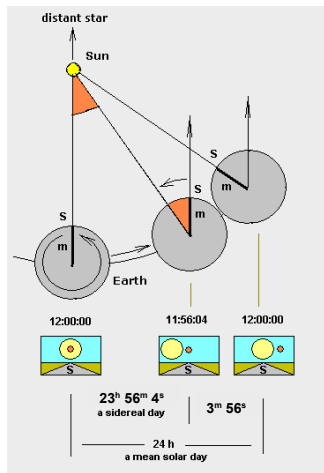
Declination typically specified in degrees:

3 degrees, 24 minutes, 13 seconds is written as: $3^{\circ}24'13''$

Parameter	Value in $^{\circ} ' ''$	Value in Decimal $^{\circ}$	Value in $^{\text{hms}}$
Full Circle	$360^{\circ}0'0''$	360.0°	$24^{\text{h}}0^{\text{m}}0^{\text{s}}$
1^{h}	$15^{\circ}0'0''$	15.0°	$1^{\text{h}}0^{\text{m}}0^{\text{s}}$
1^{m}	$0^{\circ}15'0''$	0.25°	$0^{\text{h}}1^{\text{m}}0^{\text{s}}$
1^{s}	$0^{\circ}0'15''$	0.004167°	$0^{\text{h}}0^{\text{m}}1^{\text{s}}$
$1^{\circ}0'0''$	$1^{\circ}0'0''$	1.0°	$0^{\text{h}}4^{\text{m}}0^{\text{s}}$
$0^{\circ}1'0''$	$0^{\circ}1'0''$	0.0167°	$0^{\text{h}}0^{\text{m}}4^{\text{s}}$
$0^{\circ}0'1''$	$0^{\circ}0'1''$	0.000277°	$0^{\text{h}}0^{\text{m}}0.0667^{\text{s}}$

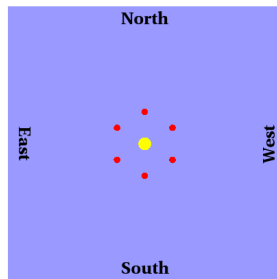
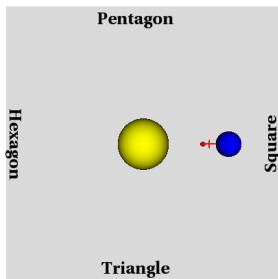
Table: Conversions between angular measures

Solar Time vs Sidereal Time



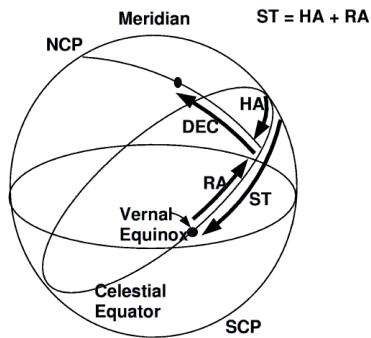
- The time from one noon to the next is called a *solar day*
- The time from one star transit to the next is called a *sidereal day*
- A sidereal day is 4 minutes less (actually 3 minutes 56 seconds) less than a solar day.

The Planet Sideron



- During one year, the sun rises and sets three times - i.e there are three solar days.
- During the same year, the constellations rise and set four times - i.e. there are four sidereal days.
- While the sun and stars rise in the east and set in the west, the sun moves from west to east with respect to the stars.

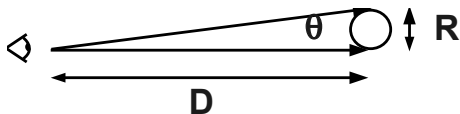
Sidereal Time and Hour Angle



- 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

Distance and Angular Size



- The distance and angular size of an object are related as follows:

$$\tan(\theta) = \frac{R}{D}$$

- For small angles, and θ measured in radians.

$$\theta = \frac{R}{D}$$

Summary

- 1 Objects in the sky are located using angles.
- 2 Alt-azimuth coordinates and Equatorial coordinates are used to describe astronomical objects:
 - Equatorial coordinates (Declination and Right Ascension) are most useful and most widely used.
- 3 Sidereal time describes the motions of the stars. A sidereal day is ≈ 4 minutes less than a solar day.
- 4 The actual size of an object, the apparent size of an object, and its distance are related. Given any two, we can calculate the third.