CELESTIAL COORDINATE SYSTEMS

- Need a way to specify the location of celestial objects
- Can be in 3D or in 2D
- Different coordinate systems exits for different purposes
- Spherical / cartesian, different origins, different orientation
- Can convert between them
HORIZONTAL COORDINATE SYSTEM

- Local observer’s horizon is the fundamental plane
- Altitude (alt) / Azimuth (az)
- Azimuth measured from north, increasing towards east
- Altitude from horizon upwards
HORIZONTAL COORDINATE SYSTEM

- Meridian is the line from North to the Zenith to South
- Azimuth 0 and 180
HORIZONTAL COORDINATE SYSTEM PROS

- Know exactly where to look

HORIZONTAL COORDINATE SYSTEM CONS

- Depends on time and location
EQUATORIAL COORDINATE SYSTEM

- Fundamental plane is the Earth’s equator
- Primary direction towards the vernal equinox
- Declination (dec) / Right Ascension (ra)
EQUATORIAL COORDINATE SYSTEM PROS

- Fixed stars have fixed coordinates
- Coordinates do not depend on time or date

EQUATORIAL COORDINATE SYSTEM CONS

- Harder to find objects
ANGLES IN ASTRONOMY

- Both coordinate systems use angles
- Multiple ways to specify angles:
  - Degrees  $0^\circ - 360^\circ$
  - Radians  $0 - 2\pi$
  - Hours    $0h - 24h$
**DEGREES**

- 1 full circle = 360°
- 1 degree = 60 arc minute = 60’
- 1’ = 60 arc seconds = 60”
- 1” = 1000 milli arc seconds = 1000 mas
- 1 mas = 1000 micro arc seconds = 1000 μas
Venus

Type: planet
Magnitude: -4.03 (extinct to: -3.76)
Absolute Magnitude: 27.33
RA/Dec (J2000.0): 5h28m23.11s/+21°20′31.4″
RA/Dec (J2017.6): 5h29m26.19s/+21°21′18.9″
Hour angle/DE: 19h21m41.41s/+21°22′26.5″ (apparent)
Az/Alt: +8°25′20.8″/+29°03′24.5″ (apparent)
Ecliptic longitude/latitude (J2000.0): +02°30′14.4″/−1°53′43.7″
Ecliptic longitude/latitude (J2017.6): +02°52′57.5″/−1°53′35.5″
Galactic longitude/latitude: 175°38′54.7″/7°20′58.3″
Obliquity (of plane, for Earth): +23°26′13.2″
Distance: 1.101AU (164,681 Mio km)
Apparent diameter: +0°00′15.2″
Sidereal period: 224.70 days (0.615 a)
Sidereal day: 5832h28m47.1s
Mean solar day: 2802h52m2s
Phase Angle: +63°45′25″
Illumination: +39°49′08″
Phase: 0.72
Illuminated: 72.1%
Venus

Type: planet
Magnitude: -4.03 (extincted to: -3.76)
Absolute Magnitude: 27.33
RA/Dec (J2000.0): 5h28m23.111/+21°20'31.4"
RA/Dec (J2017.6): 5h29m26.19s/+21°21'16.0"
Hour angle/DE: 19h21m41.41s/+21°22'26.5" (apparent)
Az/Alt: +87°25'20.8"/+29°07'24.5" (apparent)
Ecliptic longitude/latitude (J2000.0): +82°38'14.4"/-1°53'43.7"
Ecliptic longitude/latitude (J2017.6): +82°52'57.5"/-1°53'35.5"
Galactic longitude/latitude: -175°38'54.7"/-7°20'58.3"
Obliquity (of date, for Earth): +23°26'13.2"
Distance: 1.101AU (164.681 Mio km)
Apparent diameter: +0°00'15.2"
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Phase Angle: +63°45'25"
Elongation: +39°49'08"
Phase: 0.72
Illuminated: 72.1%
DEGREES, MEASURED BY HAND
HOURS

- 1 full circle = 24h
- 1h = 60 minutes = 60 m
- 1m = 60 seconds = 60 s
Venus

Type: planet
Magnitude: -4.03 (extincted to: -3.76)
Absolute Magnitude: 27.33
RA/Dec (J2000.0): 5h28m22.11s/+21°20'31.4"
RA/Dec (J2017.6): 5h29m26.19s/-21°21'18.9"
Hour angle/DE: 13°21m41.11s/+21°22'26.5" (apparent)
Az/Alt: +87°25'20.8"/+29°07'24.5" (apparent)
Ecliptic longitude/latitude (J2000.0): +82°38'14.4"/-1°53'43.7"
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CONVERSION BETWEEN COORDINATE SYSTEMS

- Not difficult, just two rotations
- Do not remember formula, but do look at it and try to understand it
- To go between RA/DEC and AZ/ALT one also needs
  - Time
  - Location
- How to specify time? Sidereal time
SIDEREAL TIME

▸ Which star is on our local meridian?
▸ Depends on time and date
▸ Our normal clocks use solar time
▸ Astronomers are interested in sidereal time
▸ Local Sidereal Time (LST) is 0 hours when the vernal equinox (RA=0) is on local meridian
SIDEREAL TIME

- Hour angle
  \[ HA = LST - RA \]
- Tells you where your object is with respect to the meridian.
- \(|HA| > 6\) hours hard to observe (but depends on declination)
EXAMPLE (WITHOUT THE CELESTIAL SPHERE)

At midnight on 1998 February 4th, LST at St. Andrews was 8h45m.

St. Andrews has longitude 2°48'W.

What was the Local Hour Angle of Betelgeuse (RA = 5h55m) at midnight?

At what time was Betelgeuse on the meridian at St. Andrews?

At what time was Betelgeuse on the meridian at Greenwich?
EXAMPLE

At midnight on 1998 February 4th, LST at St. Andrews was 8h45m.

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SOLUTIONS

2h 50m

21h 10m

20h 59m
PROBLEMS WITH THE EQUATORIAL SYSTEM

- Equatorial coordinates change slowly
- Timescale 25770 years
- This is because Earth’s rotation axis precesses around the orbital plane
- Must also specify Epoch, the standard nowadays is J2000
GALACTIC COORDINATE SYSTEM

- Earth at centre
- Latitude and longitude
- 0 towards galactic centre