Lecture 3

The Cosmic Clockwork

Celestial Sphere: Poles and Equator
Diurnal Motion; sidereal day
Annual Motion: ecliptic; seasons
Summary: Multiple motions

Apparent Brightness

• With our eyes we can assign an order of brightness (not quantitative!) to stars. Hipparchus divided stars into 5 magnitude classes
  – 1st magnitude: brightest
  – 6th magnitude: faintest visible to unaided eye
• Note
  – magnitude has no direct connection to size
  – often called apparent magnitude, since it is a combination of intrinsic brightness and distance
  – the larger the magnitude, the fainter the object
Celestial Sphere

- Apparent angular motion of astronomical objects is pretty complex. Describe as nested motions
- **Celestial Sphere**: To describe angular relationship, imagine astronomical objects painted on imaginary very large sphere
  - imagine all objects projected along your line of sight until they are on the same sphere
  - very large sphere so it appears the same from everywhere on Earth

Daily or "diurnal" motion

- **Apparent** motion (due to Earth's rotation). The whole Celestial sphere appears to rotate:
- Rotates about two points in sky (North and South **Celestial Poles**), which are projections of Earth's rotation axis into the sky. **Equatorial Plane** is projection of Earth's equator. Polaris = alpha Ursa Minoris within 1 deg of NCP
- Rotates in one **sidereal day** = 23h 56m 4.091s
Star Tracks

- Which star you can see in any geographical location depends on altitude of celestial pole in the sky, which is just the geographical latitude.
- In a very long exposure, stars make circular tracks centered on Celestial Pole.
- Location of Pole: The latitude of Madison is 43 deg North. The NCP (and Polaris) is 43 deg above the northern horizon. At the South Pole, the SCP is at the zenith.

Annual Apparent Motion

- **Apparent** motion of solar system objects (due to Earth's orbital motions):
- Describe their positions by giving position with respect to the fixed stars (i.e., "on the Celestial Sphere").
- Imagine Earth's rotation stopped, or effectively stop it by looking at intervals of exactly one sidereal day = 23h 56m.
Apparent Annual motion of the Sun

- Sun Appears to move (fairly uniformly) approximately West to East among stars at about 1 deg per day returning to the same point in one solar year.
  - Takes 24 hours ("solar day") between successive meridian crossings ("Noon"). One year = 365.2422 solar days.
  - Sun's apparent path is called the "ecliptic", and traverses 12 constellations of the "zodiac".

- **Due to Earth's orbital motion** around Sun in one Solar Year. Ecliptic defines plane of orbit

The Seasons

- Ecliptic is tilted by 23.5 deg from projection of Earth's equator into sky ("equatorial plane"). Due to tilt of earth's axis to plane of earth's orbit.
  - This tilt causes the climatic seasons: for six months sun North of equatorial plane (Northern summer, Southern winter), and vice versa.
  - **Equinox**: sun crosses equatorial plane; **solstice**: sun farthest north, south. Labeled by N. seasons.

- The constellations that are visible at midnight also change with season. Orion is a winter constellation.
The Celestial Poles

Star Trails in Hawaii
Star Trails on the Equator (Kenya)

Earth's Orbit

- Autumnal equinox
- Winter solstice
- Summer solstice
- Vernal equinox
Nighttime Constellations

Evening August Twilight
- Leo
- Sun

Evening June Twilight
- Gemini

Apparent position of Sun in August
- Leo
- Gemini
- Earth

Apparent position of Sun in June
- Gemini
- Leo
- Earth

Ecliptic