Celestial Observations

Earth experiences two basic motions:

- **Rotation** – West-to-East spinning of Earth on its axis
  \[(v_{\text{rot}} = 1770 \text{ km/hr})\]

- **Revolution** – orbit of Earth around the Sun
  \[(v_{\text{orb}} = 108,000 \text{ km/hr})\]

We do not ‘feel’ these motions, but observe their effects by watching the motions of the sky & celestial objects.
Basic observations of the sky:

• All stars appear fixed relative to each other
• Lack of depth perception
• Sun, Moon, stars, etc. rise in East, set in West in a cyclic manner

Diurnal (Daily) Motion – apparent East-to-West motion of the Sun, stars, Moon, etc. that is caused by Earth’s rotation

• Sun, Moon, and planets move West-to-East, independently from the stars

Annual Motion – apparent West-to-East motion of the Sun, Moon, and planets due to Earth’s revolution
Celestial Sphere

Model we use to describe the positions and motions of objects in the sky is the Celestial Sphere.

- Stars are fixed to an invisible sphere, centered around the Earth.
- Earth is held fixed with its rotational axis vertical.
- Earth’s reference points extended to C.S:
  - North Pole → North Celestial Pole (NCP)
  - South Pole → South Celestial Pole (SCP)
  - Equator → Celestial Equator (CE)
Celestial Sphere

- Celestial sphere rotates East-to-West around Earth to imitate diurnal motion.
Celestial Sphere

- Sun, Moon, planets move independently on the surface the Celestial Sphere to imitate *annual motion*

Ecliptic – apparent path of the Sun on the Celestial Sphere
Coordinate Systems

In order to locate anything, one needs to specify a frame of reference, an origin, and coordinates.

Geographic Coordinate System

Frame of reference: *surface of the Earth*

Origin: *Equator*

Coordinates:

*Latitude* – angle made North/South the equator

*Longitude* – angle made along the equator East/West of the Prime Meridian

SCCC (Selden)

LAT = 41° 51' 59" N
LONG = 73° 01' 54" W
The Local Sky

Horizon (Alt-Az) Coordinate System

Frame of reference: Local Sky
Origin: Local Horizon
Coordinates: Altitude – angle made above/below the horizon
Azimuth – angle made along the horizon from North, through East

Points of Reference

Zenith – point directly above an observer’s head

Celestial Meridian – imaginary line from North point on the horizon, passes through the zenith, and ends at the South point on the horizon; divides the sky into an Eastern and Western half
<table>
<thead>
<tr>
<th>Compass Point</th>
<th>Azimuth Angle</th>
</tr>
</thead>
<tbody>
<tr>
<td>North</td>
<td>0°</td>
</tr>
<tr>
<td>Northeast</td>
<td>45°</td>
</tr>
<tr>
<td>East</td>
<td>90°</td>
</tr>
<tr>
<td>Southeast</td>
<td>135°</td>
</tr>
<tr>
<td>South</td>
<td>180°</td>
</tr>
<tr>
<td>Southwest</td>
<td>225°</td>
</tr>
<tr>
<td>West</td>
<td>270°</td>
</tr>
<tr>
<td>Northwest</td>
<td>315°</td>
</tr>
</tbody>
</table>
Local Sky Diagrams

- = Back
- = Front

Zenith

30°

60°

30°

N

E

W

S
Example

Zenith

= Back

= Front

CD = ESE

Az = 110°

Alt = 60°
Effects of Observer’s Location on Local Sky

Observer’s Location: 90° N (North Pole)

- NCP is on observer’s zenith
- All stars in *Northern Celestial Hemisphere* are circumpolar
- Cannot see any of the *Southern Celestial Hemisphere*
Effects of Observer’s Location on Local Sky

Observer’s Location: 0° (Equator)

- NCP & SCP are on observer’s **horizon**
- NO stars are circumpolar
- Can see ALL of the *Northern & Southern Celestial Hemisphere* over the course of a year
Effects of Observer’s Location on Local Sky

Observer’s Location: Anywhere in Northern Hemisphere

- NCP coordinates: \( ALT = \) observer’s LAT
  \( AZ = 0^\circ \) (CD = North)
- Can see portions of the Southern Celestial Hemisphere
Warmer weather starts with greater amounts of sunlight heating the Earth’s surface.

The amount of heating by sunlight depends on the angle at which the light hits Earth’s surface.

Direct rays concentrate more light on the same area which heats the surface more.
Climate Zones

Earth is not heated uniformly across the surface because it's round.

Rays are direct at equator & become less direct towards the poles.
Climate

If the Earth’s axis were not tilted, the amount of sunlight hitting each latitude would not change during the course of the year.

No change in temperature means no Seasons.
Seasons

The tilt of Earth’s axis (23.5°) changes the angle that the sunlight hits each latitude throughout the year.
Seasons

March 21\textsuperscript{st} - Vernal Equinox
September 23\textsuperscript{rd} - Autumnal Equinox

For Long Island observers:
Sun rises: Due East   Sun sets: Due West
Noontime Altitude: \(\sim 50^\circ\)
Seasons

June 21st - Summer Solstice

For Long Island observers:
Sun rises: North of East
Sun sets: North of West
Noontime Altitude: $\sim 73.5^\circ$
December 22rd - Winter Solstice

For Long Island observers:
Sun rises: South of East   Sun sets: South of West
Noontime Altitude: $\sim 26.5^\circ$
Seasons

During the summer months the Sun stays above the horizon longer, thus heating the surface more.
Tropic Zones (LAT = 23.5° N/S)

The Sun will cross the zenith only for observers within the tropics:
- Tropic of Cancer (Summer Solstice)
- Tropic of Capricorn (Winter Solstice)
Arctic/Antarctic Circles (LAT = 66.5° N/S)

These areas will experience continuous daylight or darkness for 24 hours
Precession

The Earth’s axis *wobbles* in space because the Moon’s gravity pulls on the Earth unequally (26,000 years).
Effects of Precession

• Polaris will not always be the ‘pole star.’
• Seasons will occur during different months of the year

**TABLE 1-1** The 13 Constellations of the Zodiac

<table>
<thead>
<tr>
<th>Constellation</th>
<th>Dates of Sun’s Passage Through</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pisces</td>
<td>March 13–April 20</td>
</tr>
<tr>
<td>Aries</td>
<td>April 20–May 13</td>
</tr>
<tr>
<td>Taurus</td>
<td>May 13–June 21</td>
</tr>
<tr>
<td>Gemini</td>
<td>June 21–July 20</td>
</tr>
<tr>
<td>Cancer</td>
<td>July 20–August 11</td>
</tr>
<tr>
<td>Leo</td>
<td>August 11–September 18</td>
</tr>
<tr>
<td>Virgo</td>
<td>September 18–November 1</td>
</tr>
<tr>
<td>Libra</td>
<td>November 1–November 22</td>
</tr>
<tr>
<td>Scorpius</td>
<td>November 22–December 1</td>
</tr>
<tr>
<td>Ophiuchus</td>
<td>December 1–December 19</td>
</tr>
<tr>
<td>Sagittarius</td>
<td>December 19–January 19</td>
</tr>
<tr>
<td>Capricorn</td>
<td>January 19–February 18</td>
</tr>
<tr>
<td>Aquarius</td>
<td>February 18–March 13</td>
</tr>
</tbody>
</table>