Chapter 2
Discovering the Universe for Yourself
2.1 Patterns in the Night Sky

Our goals for learning:

- What does the universe look like from Earth?
- Why do stars rise and set?
- Why do the constellations we see depend on latitude and time of year?
What does the universe look like from Earth?

With the naked eye, we can see more than 2,000 stars as well as the Milky Way.

Comet Hyakutake, 1996
The Milky Way is our view into the plane of our galaxy

The term Milky Way is used in two ways: for the band of light in the sky and the name of our galaxy
The Milky Way

When we look out of the galactic plane (white arrows), we have a clear view to the distant universe.

When we look in any direction into the galactic plane (blue arrows), we see the stars and interstellar clouds that make up the Milky Way in the night sky.
We measure the sky using *angles*

Note: Can have same angle for very different size objects (for example Sun and Moon)
Angular Measurements

- Full circle = 360°
- 1° = 60’ (arcminutes)
- 1’ = 60” (arcseconds)
Thought Question

The angular size of your finger at arm’s length is about 1°. How many arcseconds is this?

- 60 arcseconds
- 600 arcseconds
- $60 \times 60 = 3,600$ arcseconds
Thought Question

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Angular Size versus Physical Size

angular size = physical size \times \frac{360 \text{ degrees}}{2\pi \times \text{distance}}

An object’s angular size appears smaller if it is farther away.
**Constellation**: a *region* of the sky with well defined borders

◊ **88 constellations** fill the entire sky

Red lines mark official [IAU] borders of several constellations near Orion

Yellow lines connect recognizable patterns of stars within constellations

Sirius, Procyon and Betelgeuse form a pattern spanning several constellations, called the Winter Triangle
Thought Question

The brightest stars in a constellation...
• all belong to the same star cluster.
• all lie at about the same distance from Earth.
• may actually be quite far away from each other.
Thought Question

The brightest stars in a constellation…

• all belong to the same star cluster.
• all lie at about the same distance from Earth.
• may actually be quite far away from each other.
The Celestial Sphere

Stars at different distances all appear to lie on the celestial sphere.
The Celestial Sphere

The celestial poles (north and south) are directly above Earth’s poles.

The ecliptic is the Sun’s apparent annual path around the celestial sphere.

Angle between the two is 23.5 degrees.

The celestial equator is a projection of Earth’s equator into space.
The Celestial Sphere

The 88 official constellations cover the celestial sphere.

Path of Sun projected on the celestial sphere, also defines the ecliptic plane.
The band of light from the Milky Way makes a circle around the celestial sphere.
The Local Sky

• From any place on Earth, the local sky looks like a dome (hemisphere).
• An object’s **altitude** (above horizon) and **direction** (or **azimuth**) (along horizon [boundary between earth and sky]) specify its location in your local sky.
The Local Sky

**Zenith:** The point directly overhead

**Horizon:** All points 90° away from zenith

**Meridian:** Imaginary line passing through zenith and connecting N and S points on the horizon
Review: Coordinates on the Earth

- **Latitude**: position north or south of equator
- **Longitude**: position east or west of prime meridian (runs through Greenwich, England)
Why do stars rise and set?

Earth rotates west to east, so stars appear to circle from east to west.
Our view from Earth:

Stars near the north celestial pole are circumpolar and never set [they remain above horizon]

We cannot see stars near the south celestial pole.

All other stars (and Sun, Moon, planets) rise in east and set in west. [They have daily circles, partly above the horizon and partly below it]

A circumpolar star never sets

This star never rises

Celestial equator

Your horizon [for 40° N]
Exploring the Motion of the Sky with the celestial Sphere
Thought Question

What is the arrow pointing to?
A. The zenith
B. The north celestial pole
C. The celestial equator
Thought Question

What is the arrow pointing to?

A. The zenith

B. The north celestial pole

C. The celestial equator
Why do the constellations we see depend on

• **Latitude?**
  because your position on Earth determines which constellations remain above or below the horizon.

• **Time of year?**
  because Earth’s orbit changes the apparent location of the Sun among the stars.

**Note:** Although the local sky varies with latitude, it does **not** vary with longitude. Example: Charleston (NC) and San Diego (CA) at same latitude will see the same set of constellations at night.
The sky varies with latitude but not longitude.

Altitude of celestial pole in your sky = latitude
Altitude of the celestial pole = your latitude
Thought Question

The North Star (Polaris) is 50° above your horizon, due north. Where are you?

- You are on the equator.
- You are at the North Pole.
- You are at latitude 50°N.
- You are at longitude 50°E.
- You are at latitude 50°N and longitude 50°E.
Thought Question

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- You are on the equator.
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The sky varies as Earth orbits the Sun

• As the Earth orbits the Sun, the Sun appears to move eastward along the ecliptic.

• At midnight, the stars on our meridian are opposite the Sun in the sky.

Sun's Apparent Path through the Zodiac
Special Topic: How Long Is a Day?

- **Solar day** = 24 hours = average time it takes Sun to make one full circle around our sky
- **Sidereal day** (Earth’s rotation period) = 23 hours 56 minutes = average time it takes a star to make one full circle around our sky
What have we learned?

• What does the universe look like from Earth?
  — We can see over 2,000 stars and the Milky Way with our naked eyes, and each position in the sky belongs to one of 88 constellations.
  — We can specify the position of an object in the local sky by its altitude above the horizon and its direction along the horizon.

• Why do stars rise and set?
  — Because of Earth’s rotation
What have we learned?

• Why do the constellations we see depend on latitude and time of year?
  — Your location determines which constellations are hidden by Earth.
  — Time of year determines the location of the Sun in the sky.