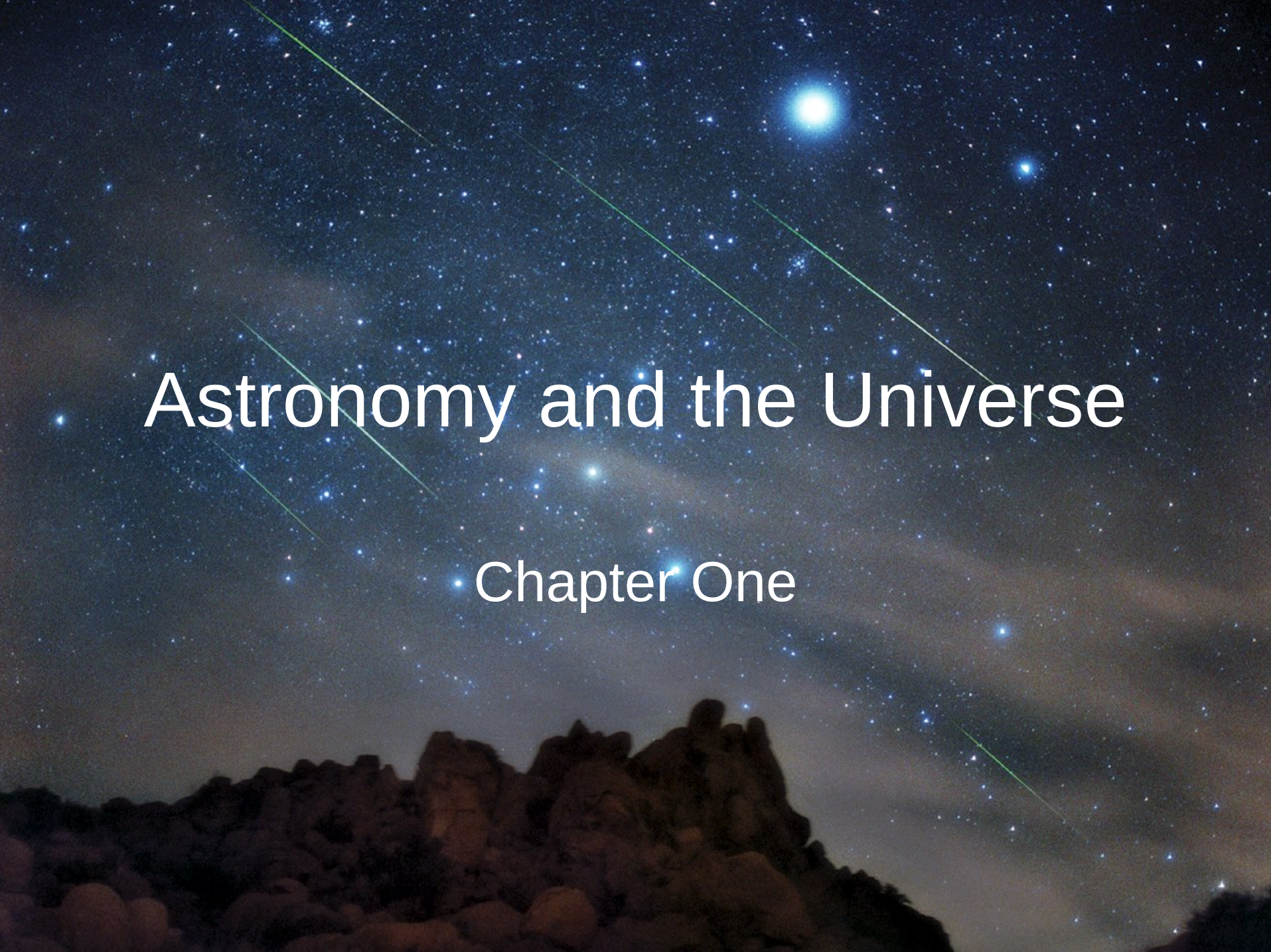


Astronomy and the Universe

Chapter One

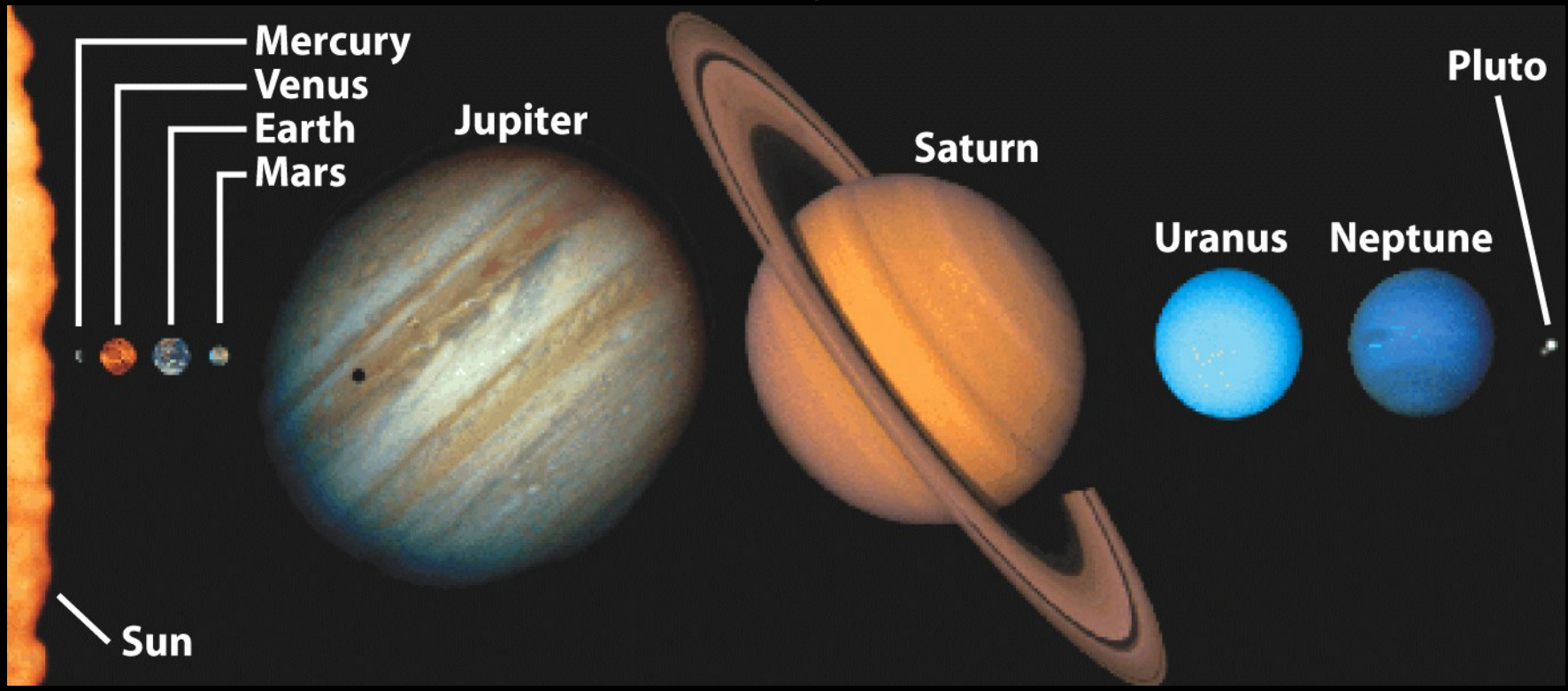
Guiding Questions

1. What methods do scientists use to expand our understanding of the universe?
2. What makes up our solar system?
3. What are the stars? Do they last forever?
4. What are galaxies? What do astronomers learn by studying them?
5. How does measuring angles help astronomers learn about objects in the sky?
6. What is powers-of-ten notation, and why is it useful in astronomy?
7. Why do astronomers measure distances in astronomical units, light-years, and parsecs?
8. How does studying the cosmos help us on Earth?

To understand the universe, astronomers use the laws of physics to construct testable theories and models

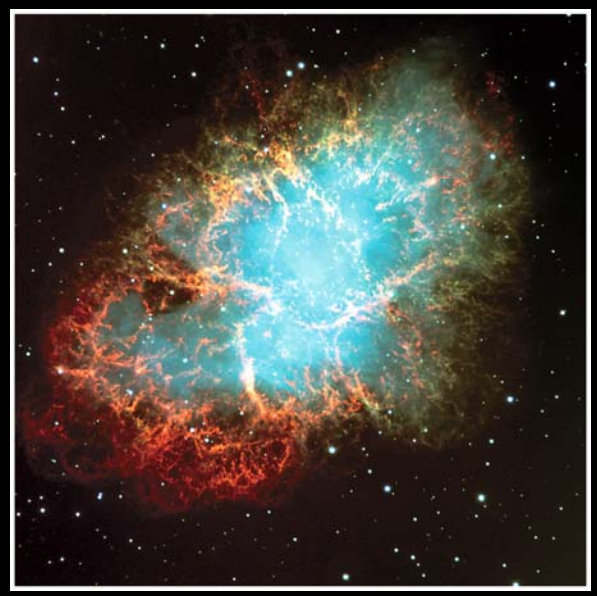
- **Scientific Method**
  - A reiterative process based on observations, logic, and skepticism
- **Hypothesis**
  - A concept or idea that seems to explain a phenomenon or set of observations
- **Model**
  - A set of hypotheses that have withstood observational or experimental tests
- **Theory**
  - A set of related hypotheses can be pieced together into a self consistent description of natural observations
- **Laws of Physics**
  - Theories that accurately describe the workings of physical reality, and have stood the test of time and been shown to have great and general validity

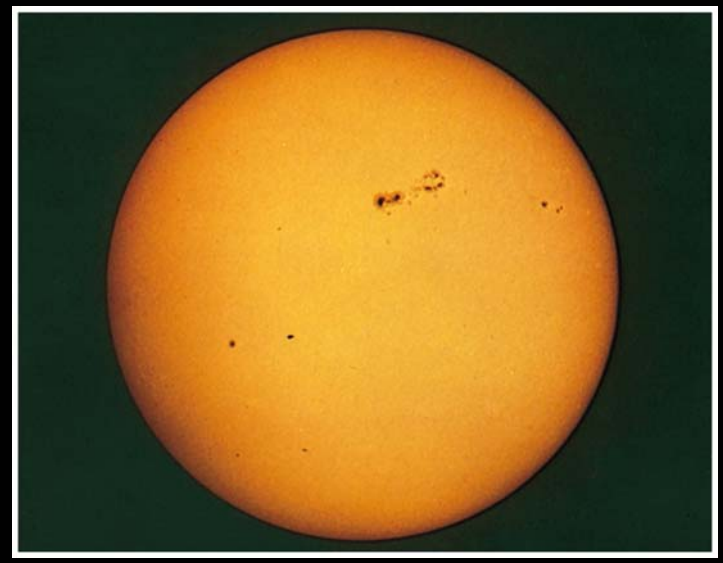
By exploring the planets, astronomers uncover clues about the formation of the solar system



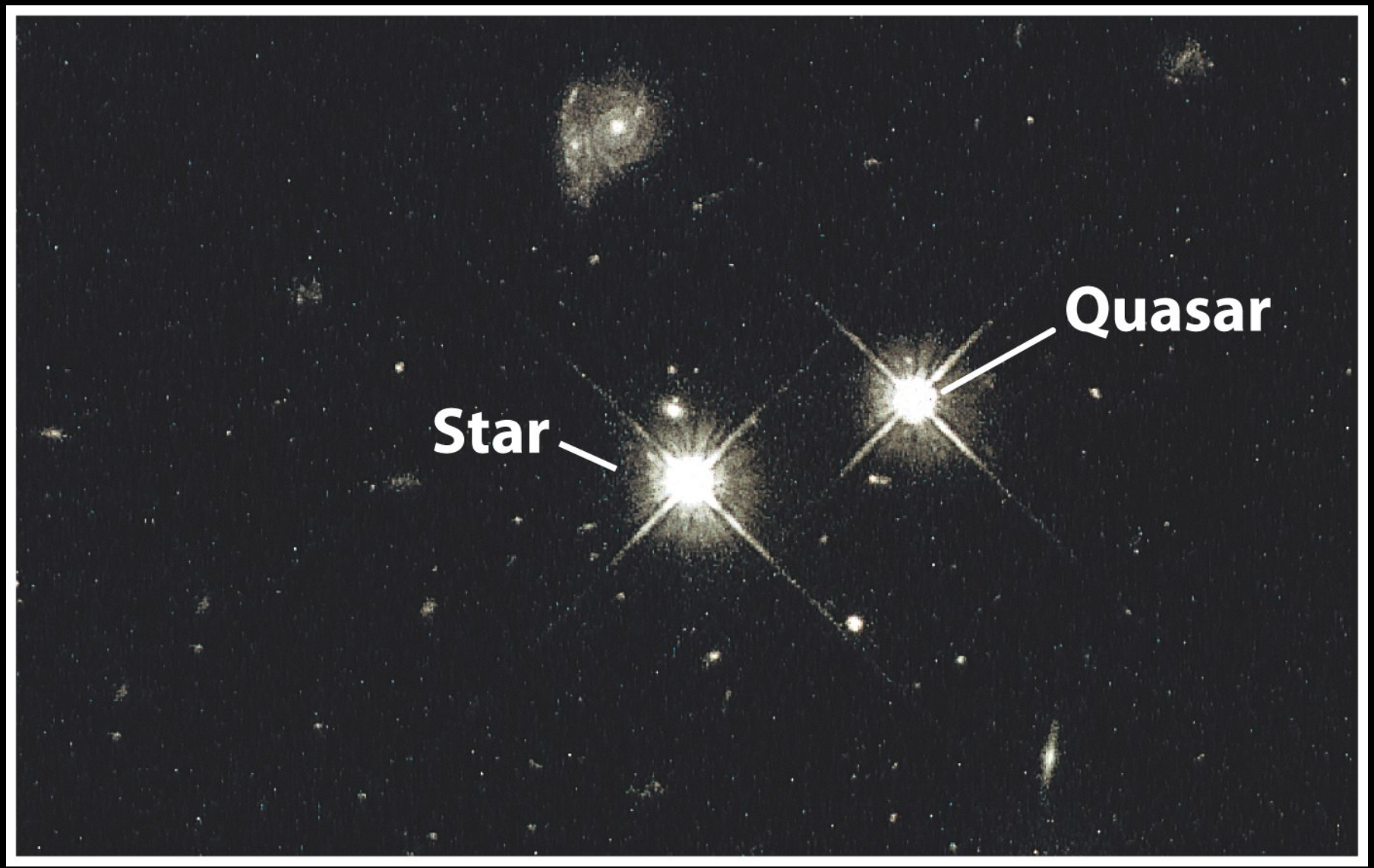
- The star we call the Sun and all the celestial bodies that orbit the Sun
  - including Earth
  - the other eight planets
  - all their various moons
  - smaller bodies such as asteroids and comets

By studying stars and nebulae, astronomers discover how stars are born, grow old, and die

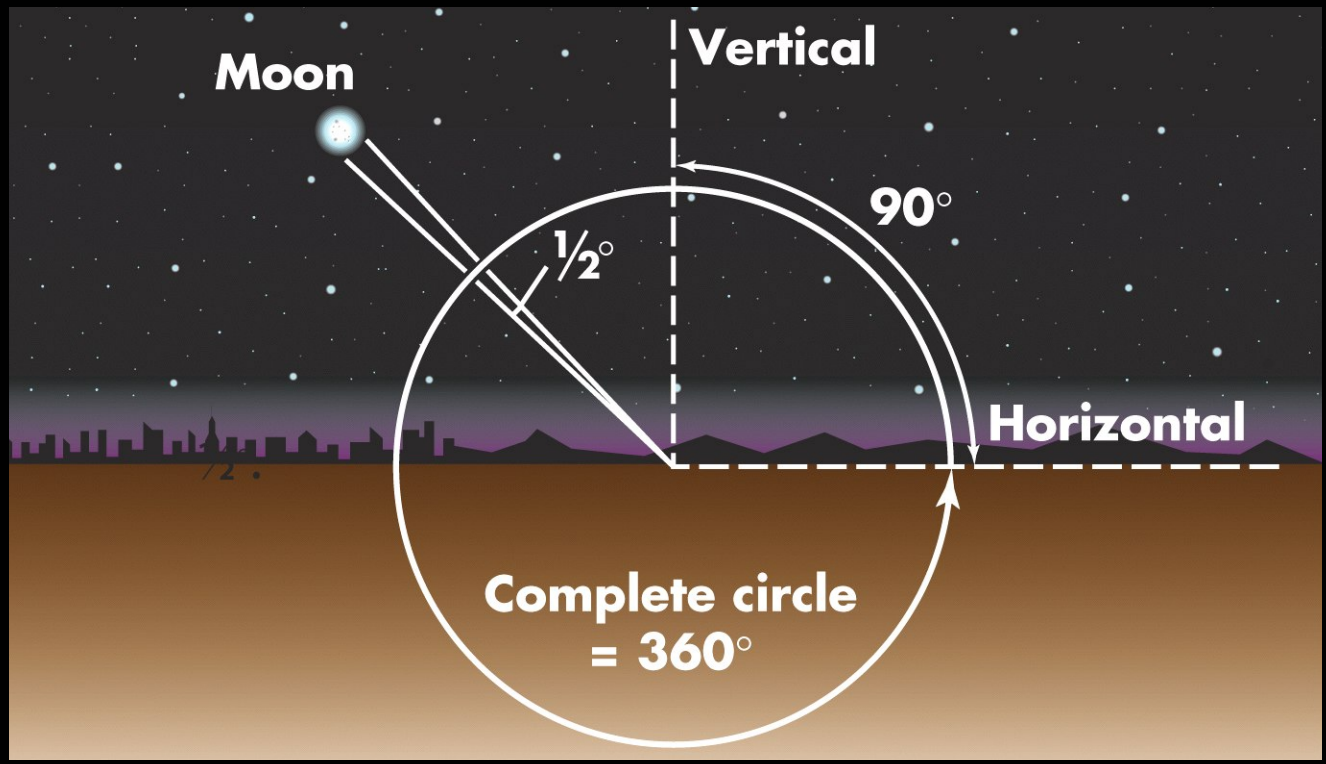




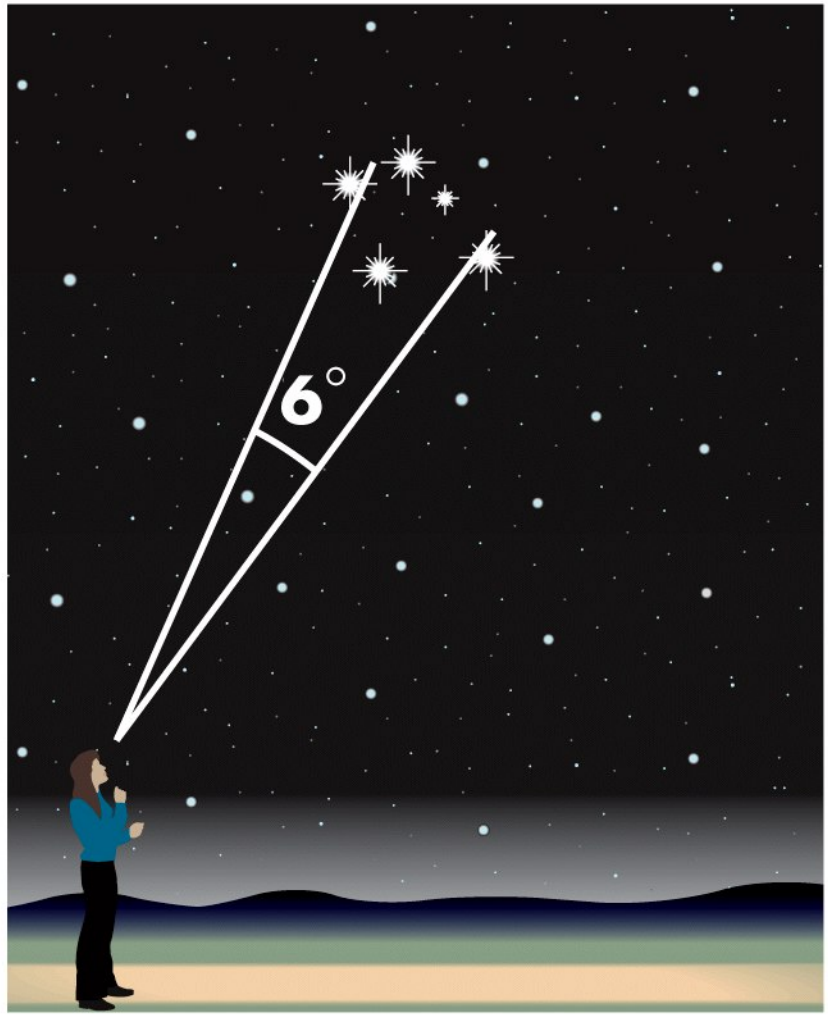
By observing galaxies, astronomers learn about the origin and fate of the universe


Quasar
Star

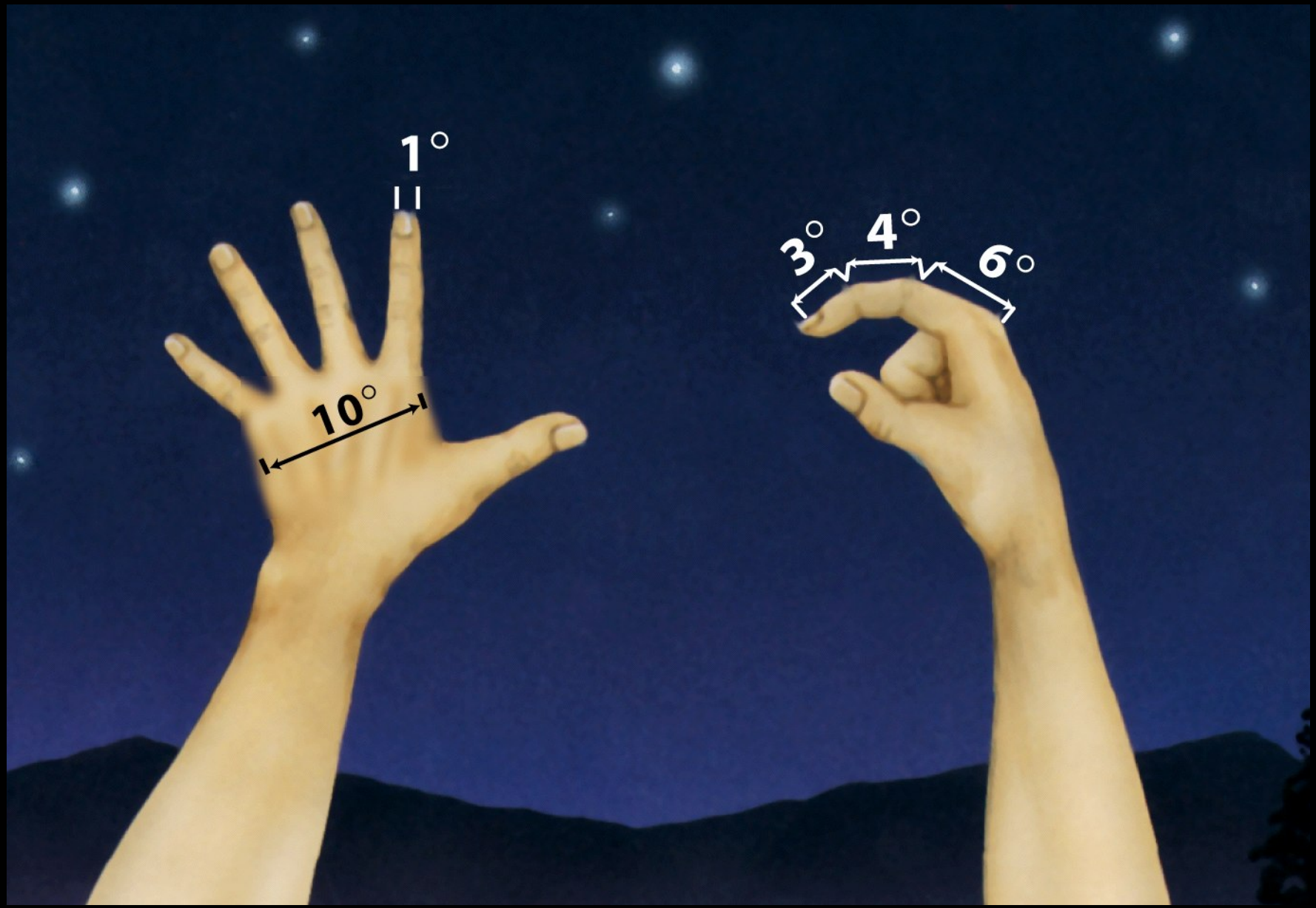
Astronomers use angles to denote the positions and apparent sizes of objects in the sky



- The basic unit of angular measure is the **degree (**°).
- Astronomers use angular measure to describe the apparent size of a celestial object—what fraction of the sky that object seems to cover
- The **angular diameter** (or **angular size**) of the Moon is ½° or the Moon **subtends** an angle of ½°.



If you draw lines from your eye to each of two stars, the angle between these lines is the **angular distance** between these two stars



The adult human hand held at arm’s length provides a means of estimating angles

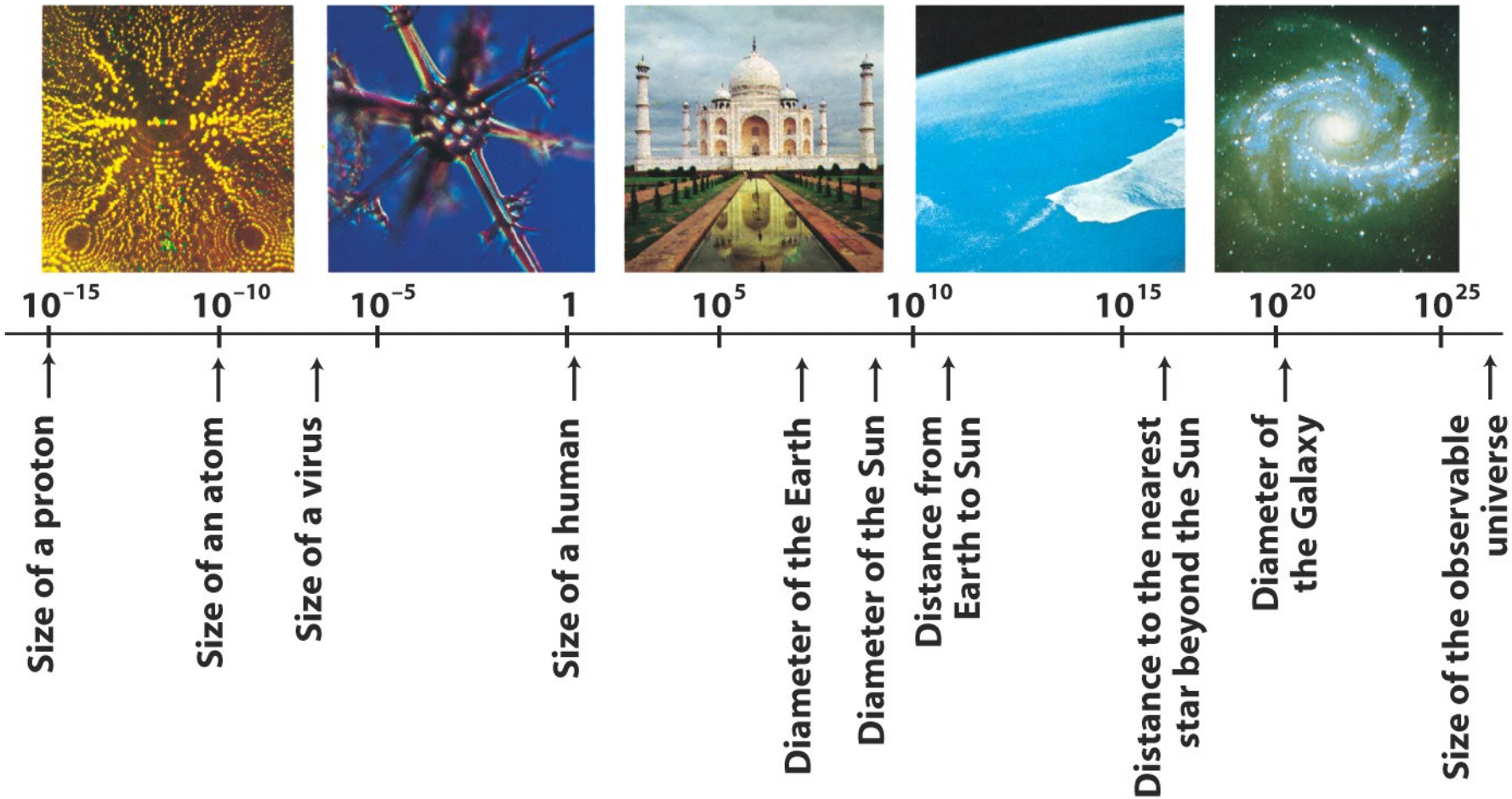
Angular Measurements

- Subdivide one degree into 60 **arcminutes**
  - minutes of arc
  - abbreviated as 60 arcmin or 60´
- Subdivide one arcminute into 60 **arcseconds**
  - seconds of arc
  - abbreviated as 60 arcsec or 60”

1° = 60 arcmin = 60´

1´ = 60 arcsec = 60”

Powers-of-ten notation is a useful shorthand system for writing numbers

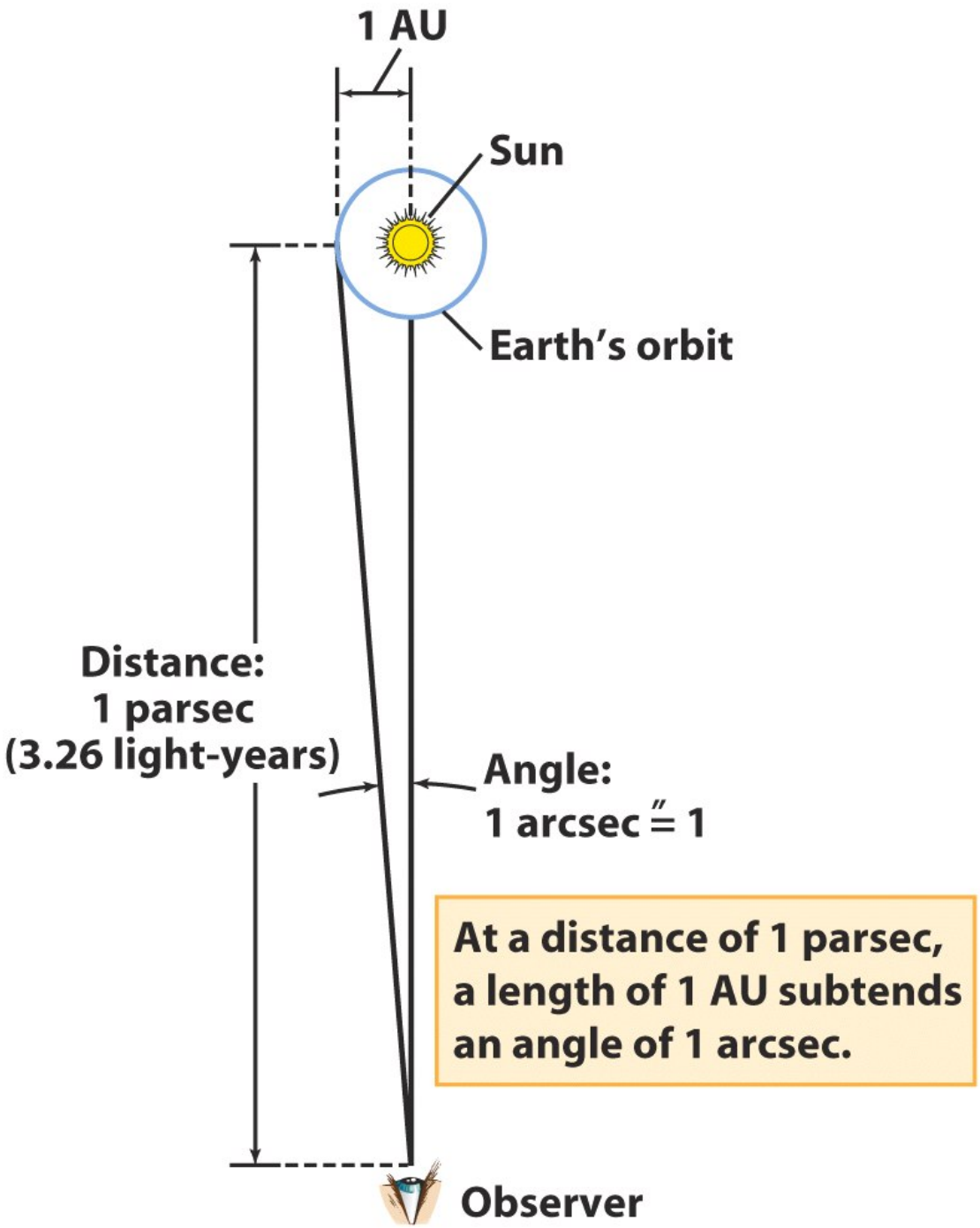


Common Prefixes for Powers of Ten

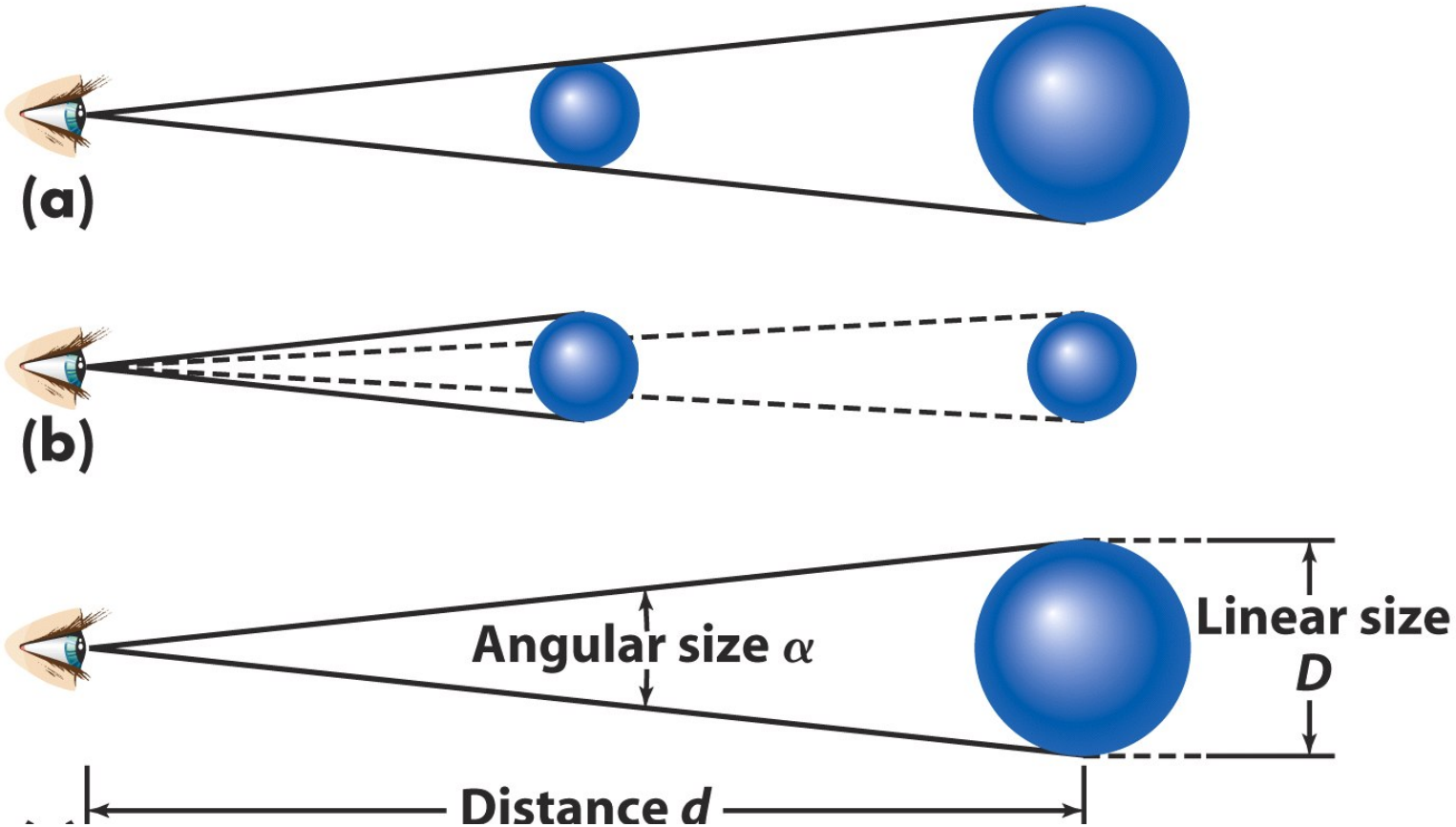
Factor		Name	Symbol
(billion)	10^{9}	Giga-	G
(million)	10^{6}	Mega-	M
(thousand)	10^{3}	kilo-	k
(hundredth)	10^{-2}	centi-	c
(thousandth)	10^{-3}	milli-	m
(millionth)	10^{-6}	micro-	μ
(billionth)	10^{-9}	nano-	n

Astronomical distances are often measured in astronomical units, parsecs, or light-years

- **Astronomical Unit (AU)**
  - One AU is the average distance between Earth and the Sun
  - 1.496 X 10^8 km or 92.96 million miles
- **Light Year (ly)**
  - One ly is the distance light can travel in one year at a speed of about 3 x 10^5 km/s or 186,000 miles/s
  - 9.46 X 10^{12} km or 63,240 AU
- **Parsec (pc)**
  - the distance at which 1 AU subtends an angle of 1 arcsec or the distance from which Earth would appear to be one arcsecond from the Sun
  - 1 pc = 3.09 × 10^{13} km = 3.26 ly


1 AU
Sun
Earth's orbit
Distance:
1 parsec
(3.26 light-years)
Angle:
1 arcsec = 1″
At a distance of 1 parsec, a length of 1 AU subtends an angle of 1 arcsec.
Observer

The Small Angle Formula



D = linear size of object

a = angular size of object (in arcsec)

d = distance to the object

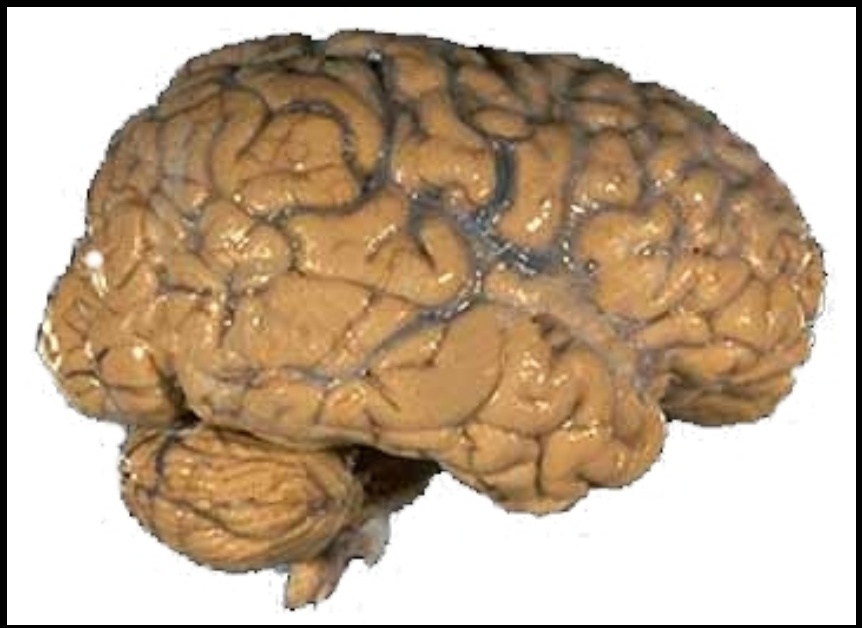
$$D = \frac{\alpha d}{206265}$$

Small Angle Formula Example

- On July 26, 2003, Jupiter was 943 million kilometers from Earth and had an angular diameter of 31.2”.
- Using the small-angle formula, determine Jupiter’s actual diameter.

$$D = \frac{31.2'' \times 943 \times 10^6\, km}{206265} = 1.43 \times 10^5\, km$$

Astronomy is an adventure of the human mind



Key Words

- angle
- angular diameter (angular size)
- angular distance
- angular measure
- arcminute
- arcsecond
- astronomical unit (AU)
- Big Bang
- black hole
- degree (°)
- exponent
- galaxy
- gamma-ray burster
- hypothesis
- kiloparsec (kpc)
- laws of physics
- light-year (ly)
- megaparsec (Mpc)
- model