Stellar Distances

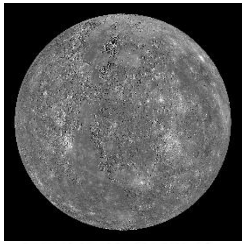
The Basic Yardsticks

- The Astronomical Unit (AU)
- The Light Year (ly)
- The Parsec (pc)

THE ASTRONOMICAL UNIT

- Astronomical Unit - average distance from the Earth to the Sun
- 1 AU = 1.5×10^8 km = 9.3×10^7 miles
- The average distance between Jupiter and the Sun is 5.2 AU.

Planets



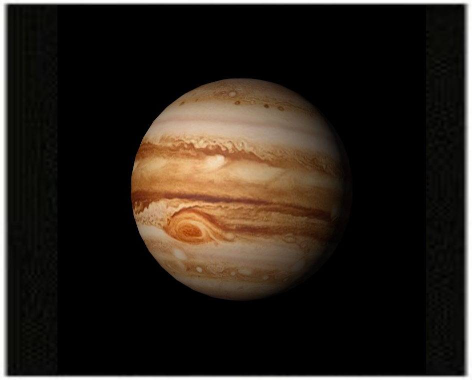
1. Mercury

0.39 AU

1 AU

3. Earth

5.2 AU

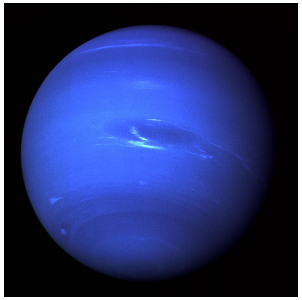


5. Jupiter

19.2 AU

7. Uranus

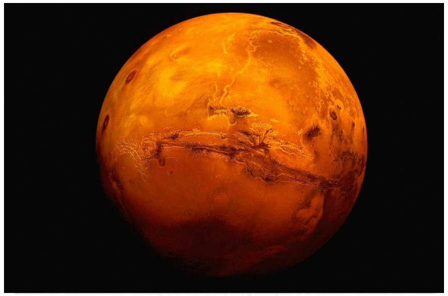
30.1 AU



8. Neptune

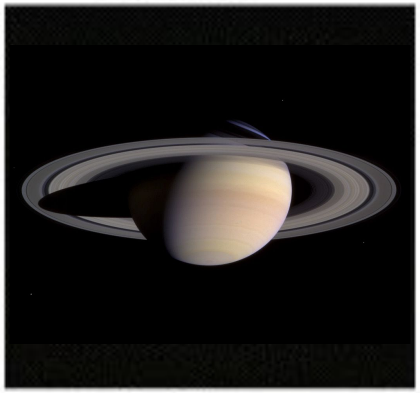
2. Venus

0.72 AU



4. Mars

1.52 AU



6. Saturn

9.57 AU

THE LIGHT YEAR

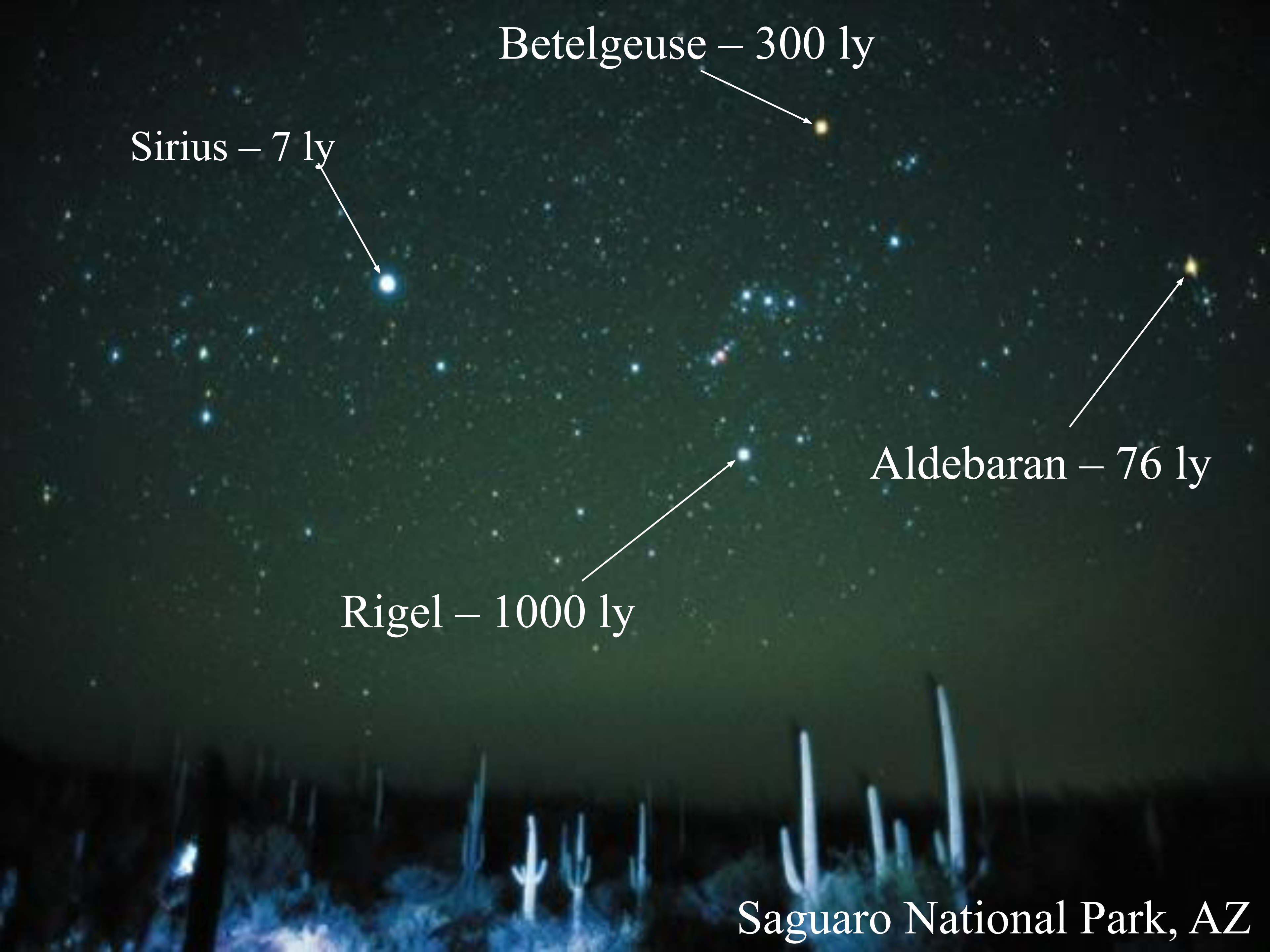
- One light year is the distance a beam of light travels during a one year trip across the void of space.

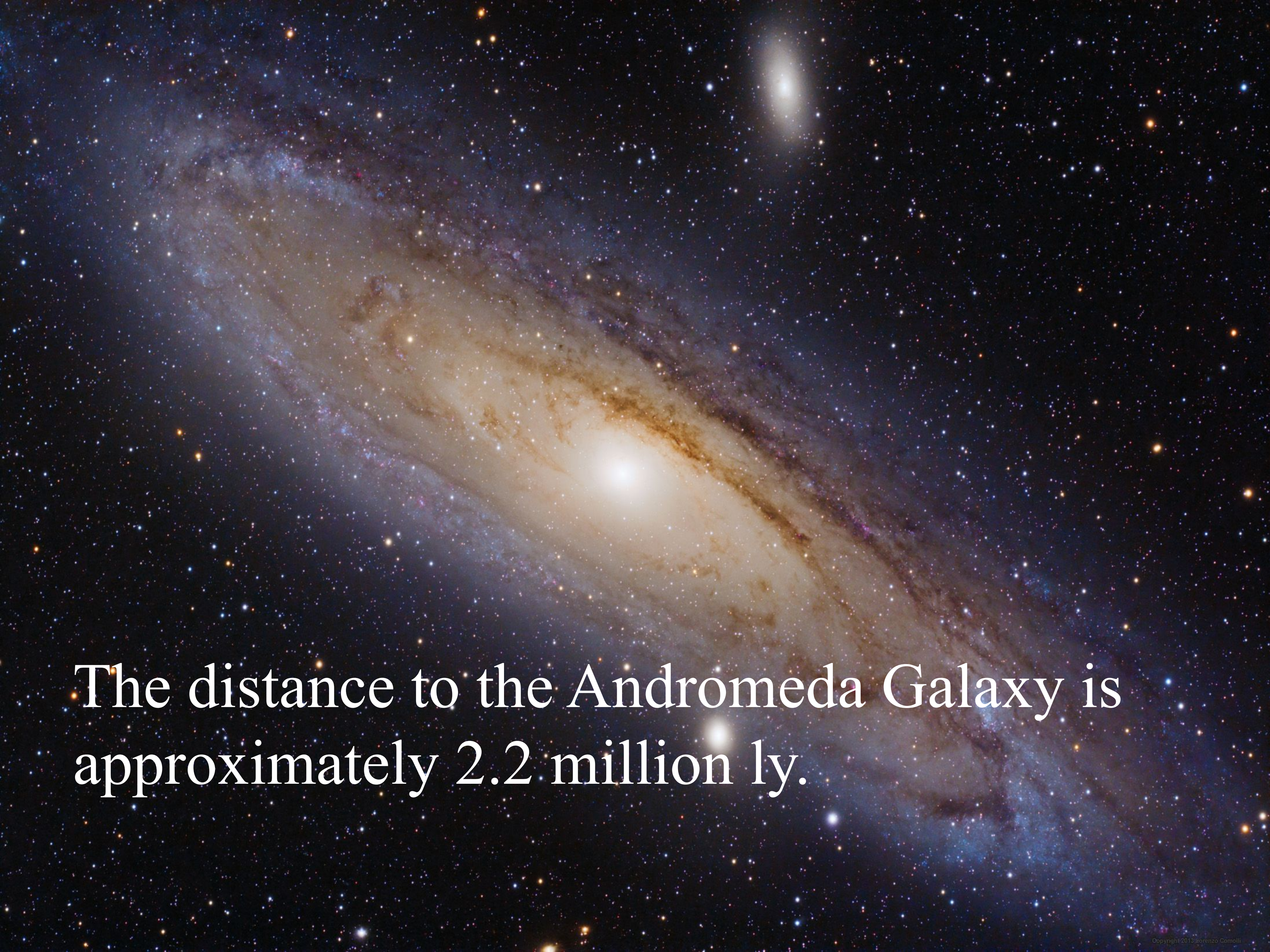
- Speed of Light = 186,000 miles/second

- 3×10^8 meters/second

- 1 ly = 63,240 AU= 9.46×10^{12} km $\simeq$ 6 trillion miles

- Proxima Centauri is just over 4.2 ly from Earth.
  - *FYI...in 2016 a terrestrial planet in Proxima Centauri's habitable zone was discovered!*


Betelgeuse – 300 ly
Sirius – 7 ly
Aldebaran – 76 ly
Rigel – 1000 ly
Saguaro National Park, AZ

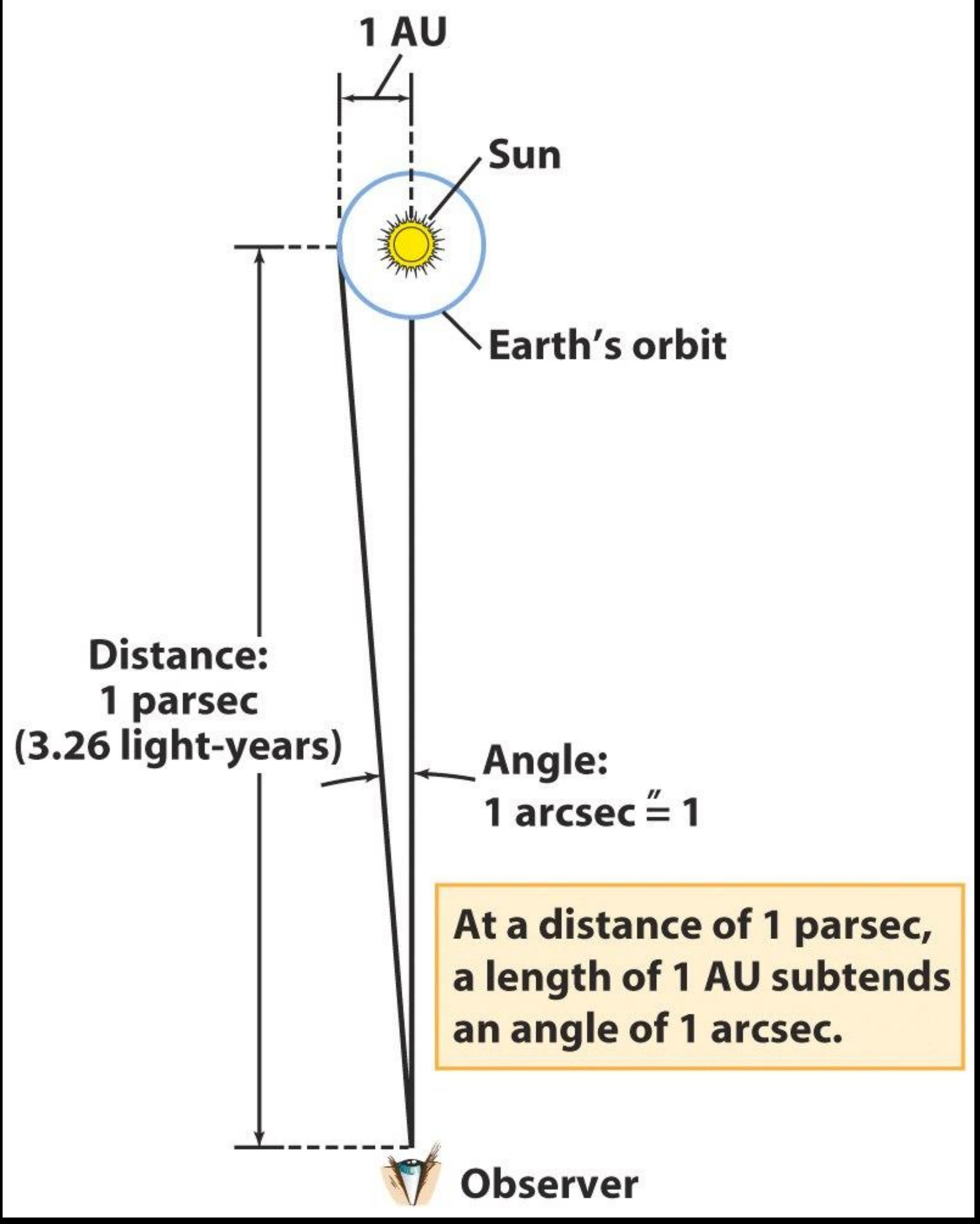


The distance to the Andromeda Galaxy is approximately 2.2 million ly.

THE PARSEC

- This distance at which 1 AU subtends an angle of 1 arcsecond (1/3600 degree).

- 1 pc = 3.09×10^{13} km = 3.26 ly
- 1 kpc = 10^3 pc
- 1 Mpc = 10^6 pc


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

Milky Way Center (made of stars, not caramel and nougat).

The distance from Earth to the center of the Milky Way Galaxy is approximately 26,000 ly or 8 kpc.

The distance to Galaxy M63 is 35 million light years or 11 megaparsecs.

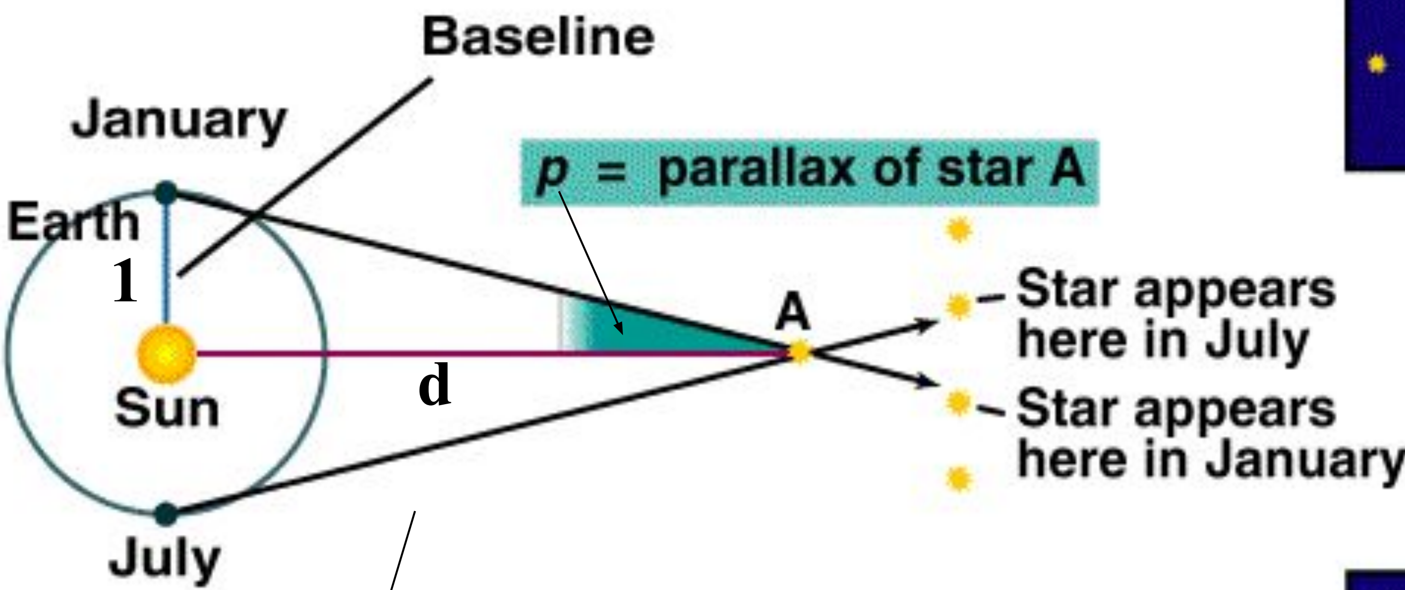
Measuring a Star's Distance

- Parallax - the apparent change in the position of a star due to the motion of the Earth; Nearby objects exhibit more parallax that remote ones.

- Distance (parsecs) = 1/(parallax angle)

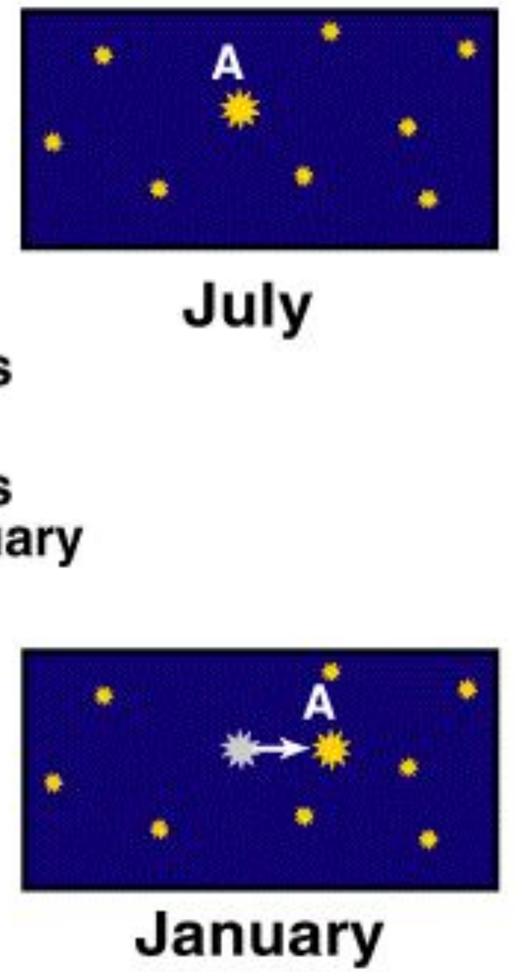
$$\boxed{d = \frac{1}{p}}$$

Parallax



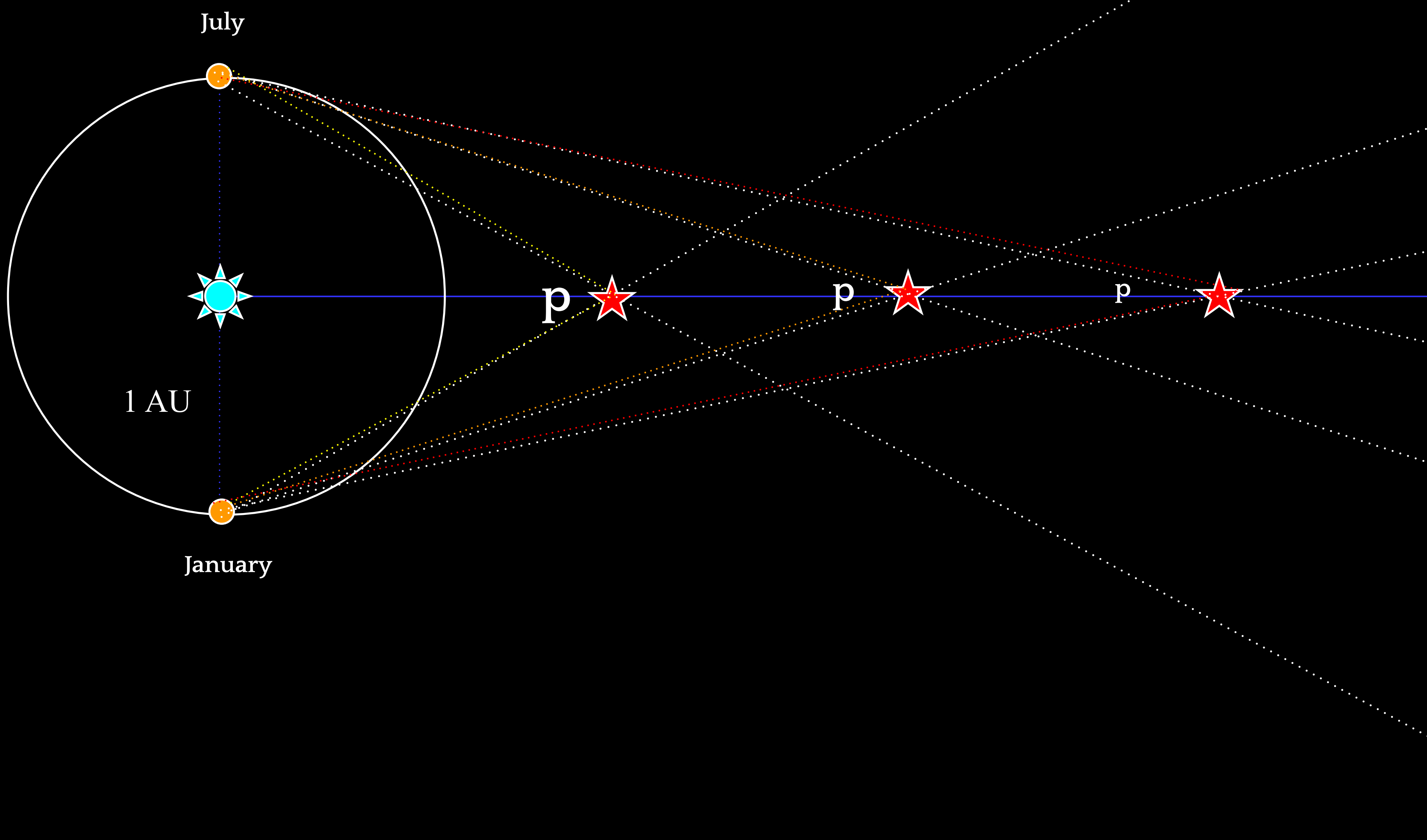
$$p = \frac{1}{d} \longrightarrow d = \frac{1}{p}$$

A



B

Heliocentric Stellar Parallax



Stellar Parallax Example

- Alpha Centauri: p = 0.756”
- d = 1/p = 1/0.756"
- d = 1.323 parsecs = 4.312 light years

Measuring a Star's Distance

- Parallax - the apparent change in the position of a star due to the motion of the Earth; Nearby objects exhibit more parallax that remote ones.

- Distance (parsecs) = 1/(parallax angle)

$$\boxed{d = \frac{1}{p}}$$

Stellar Parallax

- All Known Stars: $p < 1.0''$

- This means that there are no stars closer than 1 pc (3.26 ly)!

- Most of the brightest stars in the sky are so distant that their parallax angles can not be measured!
  - They are bright due to their amazing luminosities!!!!!!

BRIGHTNESS

- *Stellar brightness is affected by ….*
  - Distance
  - Size
  - Temperature

Luminosity

- *There are two brightness scales…*
  - Apparent Magnitude
  - Absolute Magnitude

Luminosity

- Surface temperature and surface area determine the luminosity of a star.
- Luminosity : the rate at which a star radiates energy.

Absolute Magnitude (M_v)

- The magnitude that a star would have if it were 10 parsecs away from Earth.
- **<u>Absolute magnitude is another way to represent a star's luminosity.</u>**
- To calculate M_v, you must know the star's apparent magnitude and distance (using the parallax method).

Absolute Magnitude & Luminosity

Absolute Magnitude	Luminosity (x Sun)
-5	10,000
0	100
5	1
10	0.01

How useful is Absolute Magnitude?

- A star’s luminosity is affected by…
  - Size
  - Temperature

- These things determine the luminosity and hence the absolute magnitude (M).

- A star’s ‘M’ can easily be determined by examining its temperature (*spectroscopy*).

- Once we have ‘m’ and ‘M’, we have another way to determine the distance to that star without using parallax.

- Distance Modulus = $m_v - M_v$
- $m_v - M_v = 5 \log d - 5$
- Where d is the distance to the star in parsecs.

Distance Modulus (m-M)	Distance d (pc)
-4	1.6
-2	4.0
0	10
2	25
4	63
10	1,000
15	10,000
20	100,000