

Grade 12 Earth and Space Science

SES4U

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Chapter 1

Unit 1: Astronomy

1.1 Episode 1: Standing up in the Milky Way

1. What is responsible for creating wind and keeping everything in the solar system in its clutches?
 - Gravity
2. What lies between Mars and Jupiter?
 - The asteroid belt
3. What had to be invented before we could discover Saturn and Neptune
 - The telescope
4. What is the name of the spacecraft that has travelled the farthest away from Earth?
 - Voyager 1
5. What is the Oort Cloud?
 - A cloud of billions of ice planetesimals surrounding the sun
6. What is the "address" of Earth in the cosmos?
 - Earth, Solar System, Orion Arm, Milky Way, Local Group, Virgo Supercluster, Laniakea Supercluster, Universe
7. Who was able to prove Giordano Bruno right 10 years after his death?
 - Galileo

1.2 Episode 4: A Spacetime Odyssey

1. Why do we see the Sun rise before it is over the horizon?
 - Because Earth's atmosphere refracts the Sun's image
2. How far away is Neptune from Earth (in light hours)?

- 4.17 light hours
3. Using the idea of how fast light travels, how do scientists know our universe is older than 6500 years?
 - We know that there are objects farther than 6500 light year away from Earth.
 4. Why does no one know what happened before the Big Bang?
 - No evidence survived
 5. How long after the Big Bang did it take for stars to form?
 - Millions of years
 6. What did Einstein call the “rules” that must be obeyed when traveling at high speeds?
 - Principle of relativity

1.3 Measuring the Universe

1.3.1 Some important constants

The speed of light c :

$$c = 3.00 * 10^8 \frac{m}{s} (3SD)$$

The distance of a light year:

$$\text{A light year} = 9.4608 * 10^{15} m (3SD)$$

The distance between **Earth** and **Sun** refers to the *Astronomical Unit (AU)*

$$AU = 1.4958 * 10^{11} m (3SD)$$

One Parsec is **3.26** light years

$$\text{Parsec} = 3.0824 * 10^{16} m (3SD)$$

1.3.2 Unit Conversion

Example. If 1 inch = 2.54 cm, then 4.5 inches is equivalent to how many cm?

$$4.5 \text{ inch} * \frac{2.54 cm}{1 \text{ inch}} = 11.43 \text{ cm}$$

$$\therefore 1 \text{ inch} = 2.54 \text{ cm}$$

1.3.3 Radar

This method is very accurate, it can measure the distance to the moon with an **3 cm** precision!

Using radar in Astronomy has some limitations:

- Electromagnetic waves tend to *spread out with distance* causing weaker signals
- The furthest we can measure with this technique is *with a few AUs*

1.3.4 Parallax

Parallax refers to how closer objects appear to move compared to farther away objects. This is commonly used in video games to give the illusion of depth.

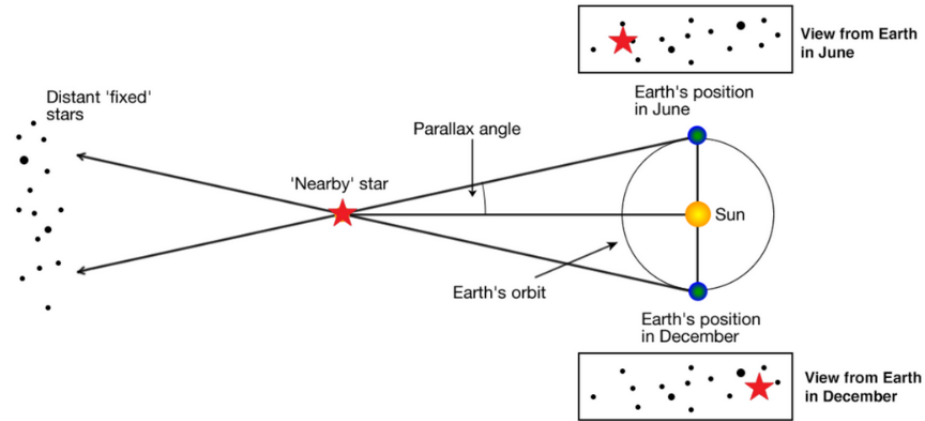


Figure 1.1: Parallax

If we measure the angles that a star shifts using arcseconds, we arrive at how the **persec is defined**

$$d = \frac{1}{p} \quad (1.1)$$

d = distance in Parsec
 p = parallax angle in arcseconds

*Remainder: The distance that can accurately be measured from the Earth using parallax is **100 parsecs**.*

1.4 Cepheid Variable Stars, Redshift and Hubble's Law

1.4.1 Apparent Magnitude and Absolute Magnitude

In this chapter, I will directly define few terms:

Definition 1.4.1. *Apparent magnitude* = *How bright an object appears from Earth's surface*

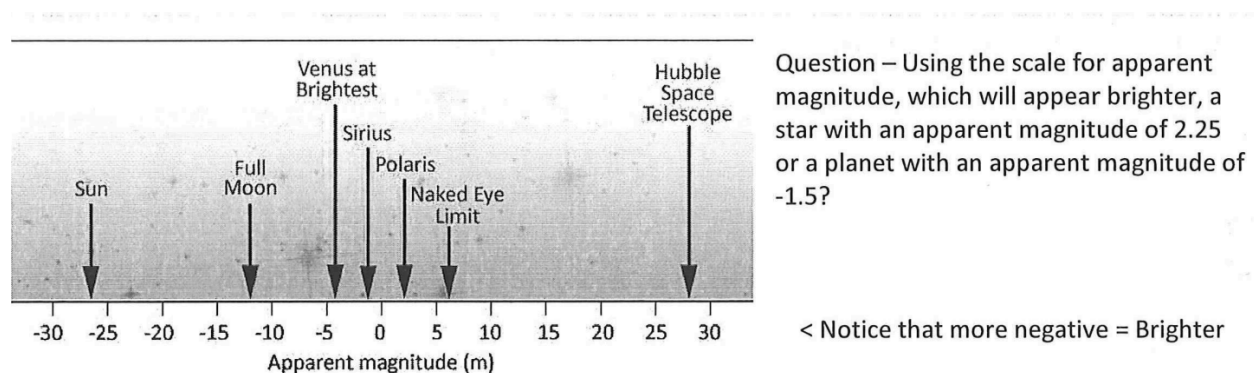


Figure 1.2: Apparent magnitude (m)

Definition 1.4.2. *Absolute Magnitude:* *How bright an object would appear if it was exactly 10 parsecs away*

1.4.2 Cepheid Variable stars

Definition 1.4.3. *Cepheids:* *Special stars that change how luminous they are at regular time intervals*

Cepheids "pulsate" with *periods* ranging from 1 to 100 days

1.4.3 Determining absolute magnitudes using Cepheid Variables

Absolute magnitudes of stars can be determined using cepheids. It was discovered that period of pulsation is directly related to the star's *luminosity*

Definition 1.4.4. *luminosity:* *The amount of energy emitted by a star each second.*

longer periods have *higher* luminosities

Cepheid Variables are also called "standard candles". Using this method, we can determine distances from 1000 parsecs up to 50 million parsecs

1.4.4 Hubble's Law

Hubble's Law states that:

The *further* away an object is, the *faster* moving away from us.

Hubble's law:

$$v = Hd$$

$$\begin{aligned} v &= \text{velocity of object in } km/h \\ d &= \text{distance in megaparsecs (Mpc)} \\ (1 \text{ Mpc} &= 1 \text{ million pc}) \\ H &= \text{Hubble's constant} \end{aligned}$$

If the velocity of an object is known, we can then calculate their distance.

1.4.5 Redshift

Luckily, people can determine the the velocity of fast-moving objects with [Redshift](#)
Remember, Doppler Effect causes red shifts