Grade 12 Earth and Space Science

SES4U

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Contents

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 ”addresss” 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 Spacetie 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 Measuing 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 *Astronomicial 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?

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

$\therefore 1\ inch = 11.43cm$

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 Parallex

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.

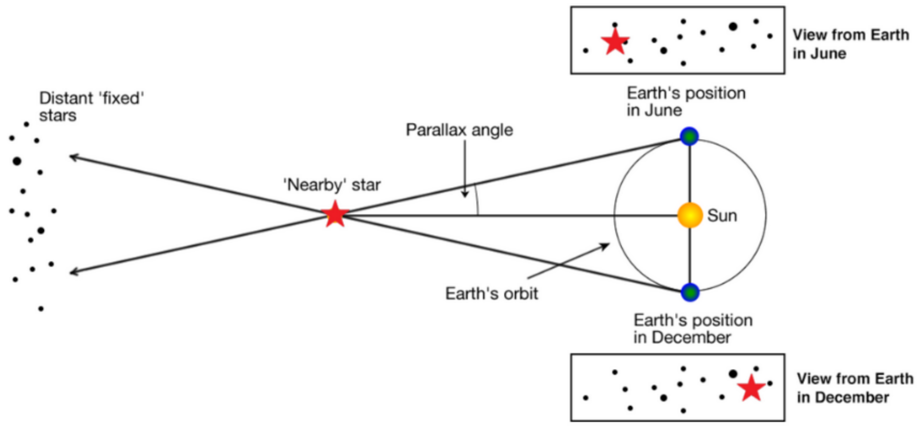

Figure 1.1: Parallax

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

$$d = \frac{1}{p} \tag{1.1}$$

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*

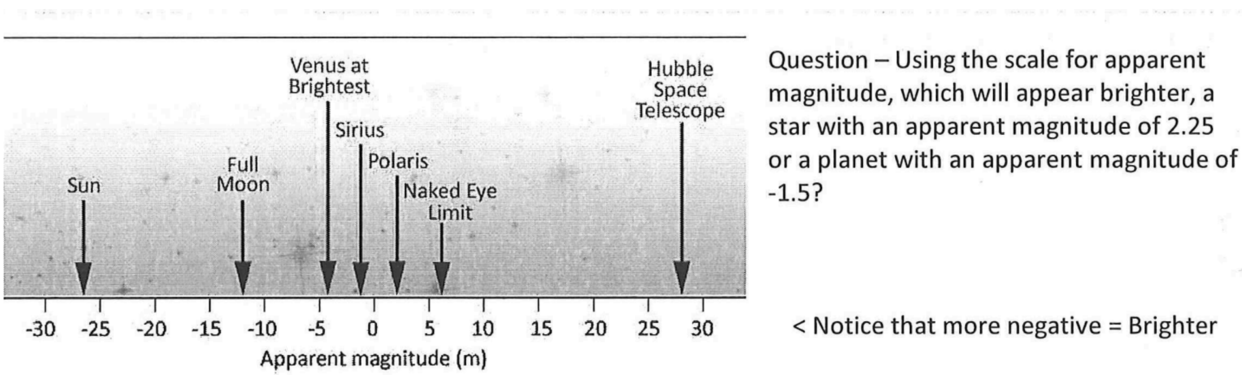

Figure 1.2: Apparent magnitude (m)

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 Cepheld Variables

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

Definition 1.4.4. *lumonosity: 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 and object is, the faster moving away from us.

Hubble's law:

$$v = Hd$$

v = velocity of object in km/h
d = distance in megaparsecs (Mpc)
(1 Mpc = 1 million pc)
H = Hubble's constant

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

1.4.6 Overall summary of this section

In this subsection, I will briefly summary what we learn for measuring the distance

To start off, we have radar:

Able to measure the distance to the moon with an 3 cm precision. **Distance:** few AUs

After Radar, we have **parallex**:

Using this formula:

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

p = parallax angle in parsec
d = distance in Parsec

We can measure objects 100 parsecs from our Earth

Then, we get **Cepheld Variables**:

We can use Cepheld's period of changes to determine lumonosity. Use period to determine the Absolute Magnitude, and use formula "Standard Candles" to determine distances.

This method can measure objects from 1000 parsecs to 50 million parsecs

Finally, we can use Redshift and Doppler Effect to determine the velocity of object:

Then use Hubble's Law:

$$v = Hd$$

v = the velocity of the object in km/h
H = Hubble constant

d = the distance of the object from our earth in Mpc

To determine further away distance of object