1 Surveying the Stars

1.1 The Doppler Effect

$$\text{Doppler shift } z = \frac{\Delta\lambda}{\lambda} = \frac{\Delta f}{f} = \frac{v}{c}$$

- The line spectrum of a star or galaxy is compared with the pattern of the prominent lines in the spectrum.
- The change of wavelength is measured.
- Then **doppler shift** calculated.

Spectroscopic binary are binary systems that cannot be resolved.

1. Each spectral line splits into two,
2. Then merges together.

1.2 Hubble's Law

1. Hubble measured **Cepheid variables** which has a known absolute magnitude depending on their period.
2. He calculated the distance to each Cepheid variable.
3. He identified that prominent spectral lines are **red-shifted to longer wavelengths**.

Hubble's law is expressed as

$$v = Hd$$

where $H = 65\text{km}\,\text{s}^{-1}\text{Mpc}^{-1}$ is Hubble's constant.

The Big Bang Theory

- **Big Bang theory** suggest the universe was created in a massive primordial explosion.
- **Steady State theory** supposed that matter enter the Universe at high holes, pushes the galaxies apart as matter enters.

Evidence for the Big Bang Theory

- **The spectrum of microwave radiation** from space matched the theoretical spectrum of thermal radiation from an object at a temperature of 2.7K.

  The radiation was created in the Big Bang, travelling through the Universe ever since the Universe became transparent. As the Universe expands, its mean temperature decreases to about 2.7K.

- **Relative abundance of hydrogen and helium -** the 3:1 ratio of hydrogen to helium by mass can be calculated by considering the cooling of the Universe.

Dark Energy

Distant type Ia supernovae are much further than expected.

- The supernovae must have been accelerating.
- Many more observations confirmed the Universe is accelerating.
- The unknown type of force causing this acceleration by releasing hidden energy called **dark energy**.

Evidence for acceleration is based on distance measurements of type Ia supernova by two different methods.

- **Hubble's law** give distance to each supernovae.
- Type Ia supernovae used as **standard candles**.

But distant type Ia supernova are dimmer and therefore further away than their red-shifted indicates.

1.3 Quasars

The quasar is an astronomical radio source with very strong lines.

- Very large red shift corresponding to a very high speed of recession.
- 1000 times more luminous than the Milky Way Galaxy, variation in brightness indicates it is much smaller than a galaxy.

Quasar Properties

- Very **powerful** light output, much greater than the light output of a star.
- Relative **small size** no greater than a solar system.
- A **large red shift** indicating distance between 5000 to 10000 million light years.

Images of quasars indicates jets of matter being ejected and galaxies nearby distorted.

1. Galaxy with supermassive black hole at its centre.
2. Mass pulled in would **become very hot** due to compression as it nears the event horizon.
3. Overheating result in clouds of hot glowing gas being thrown back into space.

Action ceases when there are no nearby stars for the black hole to consume.

1.4 Exoplanets

- **Exoplanets** are planets outside the Solar System.
- The **inhabitable zone** is the zone in which liquid water may exist on a planet.

The Radial Velocity Method

Observe the line spectrum of the light from a star to detect a **periodic Doppler shift**, because the star and the planet orbit around a **common centre of mass**.

$$v = \frac{c\Delta\lambda}{\lambda}$$

Orbital radius of a star is given by

$$v = \frac{2\pi R}{T}$$

If the **orbital plane** is inclined at angle θ to the line of sight, the orbital speed of the exoplanet is $\frac{v}{\cos\theta}$

The Transit Method

Record the **intensity of light** from the star. If the intensity regularly dips, it is likely caused by an exoplanet passing in front of the star, the exoplanet **blocks out some of the light** from the star.

- The larger the exoplanet, the greater the dip.
- By measuring the dip in intensity, the **radius of the planet** can be estimated. The **fractional drop** of intensity at each dip is equal to the ratio of the area of the exoplanet disk to the area of the star disc.

  The radius of the planet can be estimated if the radius of the star is known.

Exoplanet transit only occurs if the line of sight to the star is in the plane of the planet's orbit.