

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 $H = 65\text{km s}^{-1}\text{Mpc}^{-1}$ 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.