

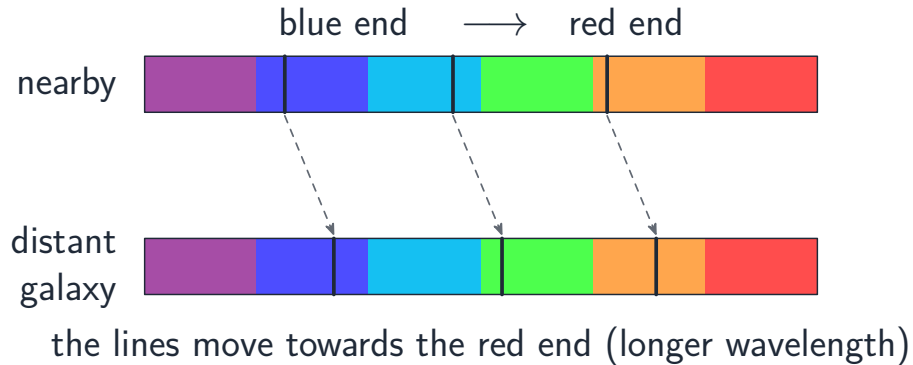
Exercise walk-through

6.2

Stars and the Universe

IGCSE Physics

The expanding Universe



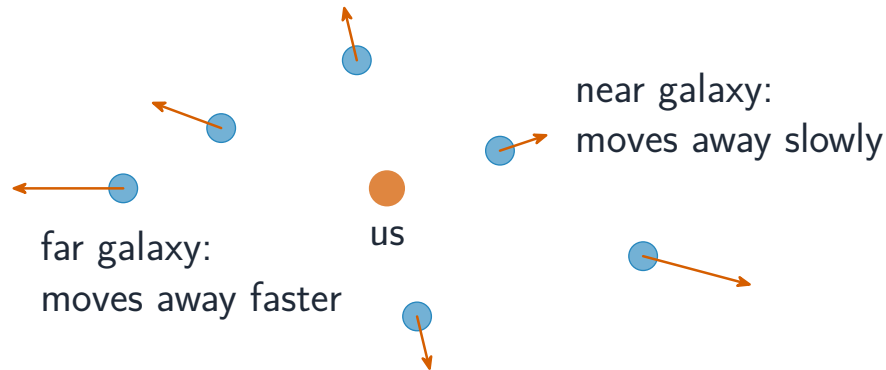
redshift : lines shift red

Distant galaxies show redshift – space itself is stretching.

Redshift $\Rightarrow$ the Universe is expanding $\Rightarrow$ it began in a hot dense state (the Big Bang).

Hubble and the age of the Universe

the Universe is expanding



$$H_0 = \frac{v}{d}, \quad \text{age} \approx \frac{1}{H_0}.$$

$$H_0 = 2.2 \times 10^{-18} \text{ s}^{-1}$$

$$\frac{1}{H_0} \approx 4.5 \times 10^{17} \text{ s} \approx 14 \text{ billion yr}$$

Every galaxy is moving away from us, and the farther ones move away faster – the Universe is expanding

Redshift, Hubble and the CMBR

Receding

When a galaxy is **receding**, the light we receive has a longer wavelength than normal – shifted towards the red end.

Hubble's law

The further away a galaxy is, the faster it recedes. The **Hubble constant** H_0 links the two: $v = H_0 d$.

The age

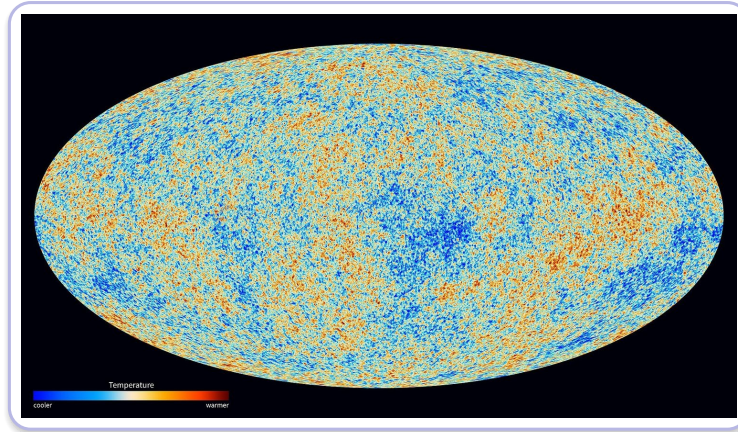
$1/H_0$ estimates the age of the Universe – how long ago everything was in the same place.

The CMBR

The **cosmic microwave background radiation**: faint microwaves from every direction, the cooled afterglow of the hot early Universe.

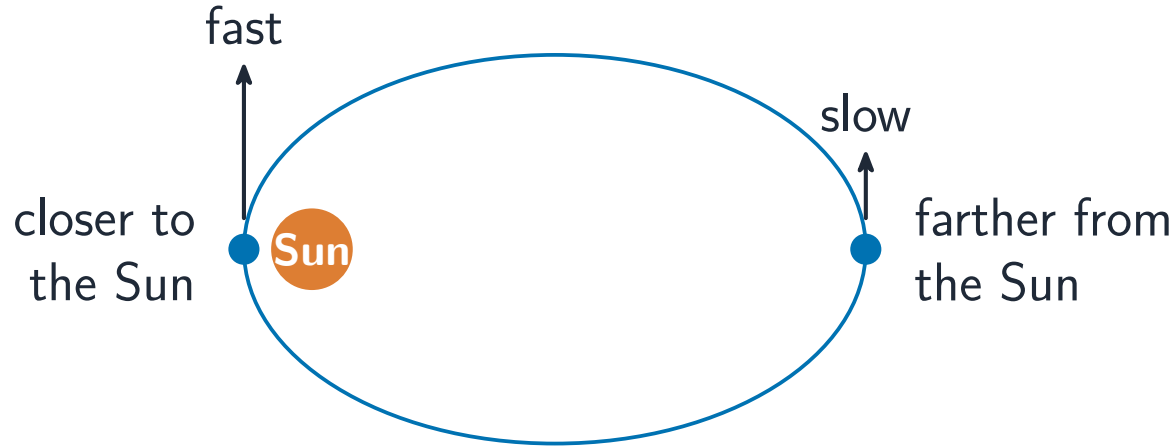
Two independent pieces of evidence pointing the same way – redshift and the CMBR – is what makes the Big Bang model hard to argue with.

More evidence and the age of the Universe



The whole sky mapped in microwaves: this faint glow reaches us from every direction as the leftover heat of the young Universe – strong evidence for the Big Bang

Orbits and gravity, continued



The Sun sits at one focus of the ellipse; the planet speeds up as it comes closer and slows down as it moves away

Exercises 2.1·3.1

2.1 State the nuclear reaction that powers the Sun.

[1]

2.2 State what a light-year measures.

[1]

3.1 Redshift of light from distant galaxies is evidence that the Universe is:

[1]

☐

A shrinking

B expanding

C unchanging

D rotating

Exercises 2.1·3.1

2.1 State the nuclear reaction that powers the Sun.

[1]

2.1

- nuclear fusion (of hydrogen nuclei into helium)

2.2 State what a light-year measures.

[1]

2.2

- distance (the distance light travels in one year)

3.1 Redshift of light from distant galaxies is evidence that the Universe is:

[1]

☐

A shrinking

B expanding

C unchanging

D rotating

3.1 B

- redshift shows galaxies are receding – the Universe is expanding

Exercise 3.2 (a)

3.2 A medium-mass star like the Sun runs out of hydrogen fuel.

(a) Describe what it becomes, in order, after this.

[3]

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[3]

(a) it swells into a red giant

- throws off its outer layers as a planetary nebula
- leaving a white dwarf

Exercise 3.2 (b)

3.2 A medium-mass star like the Sun runs out of hydrogen fuel.

(b) State what is left at the very end.

[1]

Exercise 3.2 (b)

3.2 A medium-mass star like the Sun runs out of hydrogen fuel.

(b) State what is left at the very end.

[1]

(b) a white dwarf

Exercise 3.3 (a)

3.3 The Hubble constant is about $H_0 = 2.2 \times 10^{-18} \text{ s}^{-1}$.

(a) Estimate the age of the Universe in seconds.

[2]

Exercise 3.3 (a)

3.3 The Hubble constant is about $H_0 = 2.2 \times 10^{-18} \text{ s}^{-1}$.

(a) Estimate the age of the Universe in seconds.

[2]

(a) $\text{age} \approx 1/H_0$

$$\text{age} = \frac{1}{2.2 \times 10^{-18} \text{ s}^{-1}} = \mathbf{4.5 \times 10^{17} \text{ s}}$$

Exercise 3.3 (b)

3.3 The Hubble constant is about $H_0 = 2.2 \times 10^{-18} \text{ s}^{-1}$.

(b) State one other piece of evidence for the Big Bang.

[1]

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[1]

(b) the cosmic microwave background radiation (CMBR)