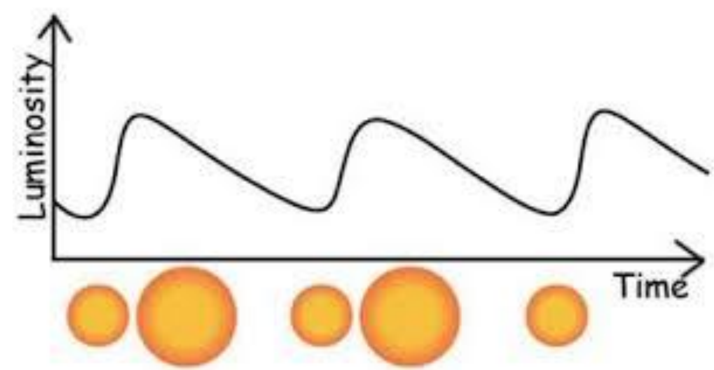
The Hubble Flow

Hubble Flow

- Hubble observed a class of variable stars known as Cepheid variables (discovered by Henrietta Swan Leavitt in 1908)
- Cepheid's are pulsating stars which have a direct relationship between the pulsation and the brightness
- This allowed them to be used as Standard candles –

  where if we know the **period**,
  we can work out the true **luminosity**
  (**absolute magnitude**),
  and if we know this we can work out
  the **distance** to the star

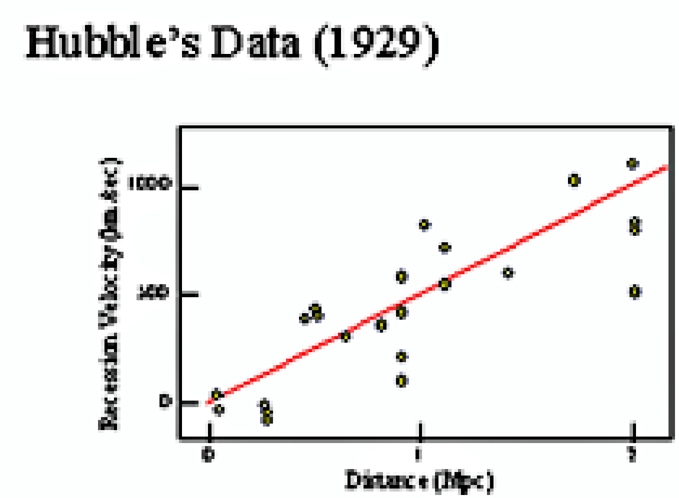


Hubble Flow

- When Hubble observed these stars he worked out that most of them were in fact outside of our galaxy
- Using these stars he measured the distances to their host galaxies and found that there was a relationship between the distance to the galaxies and the velocity of the system…

The further away they were –

the faster they were moving…

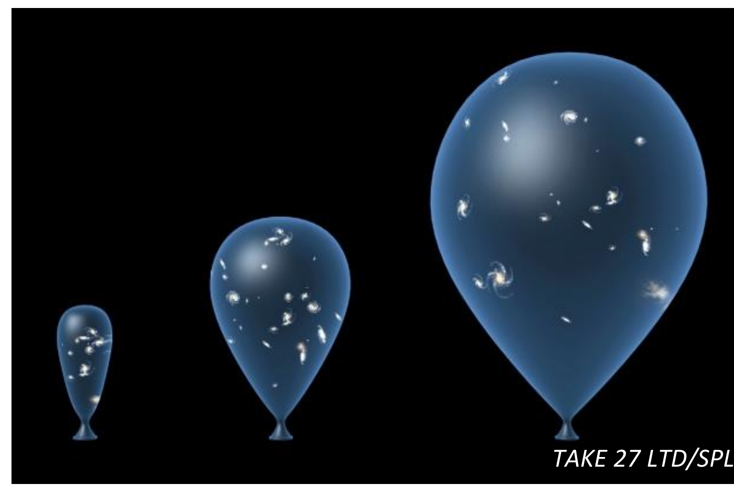


Universal Expansion

Despite the fact that Hubble himself was not in favour of the idea that his discovery 'proved' universal expansion, it is the widely accepted piece of evidence that is strongly in favour of it.

The expansion of the Universe is quite a tricky one to imagine, the best way to envisage it is through the 'Balloon Model':

Not only does the distance between two galaxies increase, but all of the intermediate space in between expands. This is just like the balloon universe image to the right; the distance between each galaxy increases but the balloon material itself also expands as it inflates.



Universal Expansion

So we do not only have galaxies receding at a certain velocity .e.g. km/s. What we actually have is a recession velocity **per unit of space**; as all space is expanding. So the units for how fast galaxies are receding from us (and other galaxies) has to take this into account and known as the Hubble Constant, which has units of:

$$kms^{-1}Mpc^{-1}$$

Recession velocity   per unit of space

Hence why the further a galaxy is away from us, the faster it is receding from us.

Exercise

- Given the data provided work out the Hubble constant, the **gradient** of the graph:

- Recession velocity Vs Distance

$$y = mx + c$$

Helpful Equations:

Hubble's Law states: $v = H_0 \times d$

Where,
v = recession velocity (km/s or kms^{-1}),
d = distance to the galaxy (Mpc) and
H_0 = the Hubble Constant (km/s/Mpc or $kms^{-1}Mpc^{-1}$) – this is the gradient of your graph

Recession velocity: $v = c \times z$

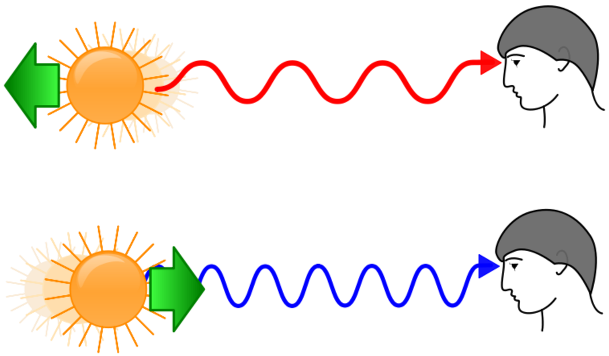
Where,
c =speed of light (300,000km/s or $3 \times 10^5 kms^{-1}$)
z = redshift

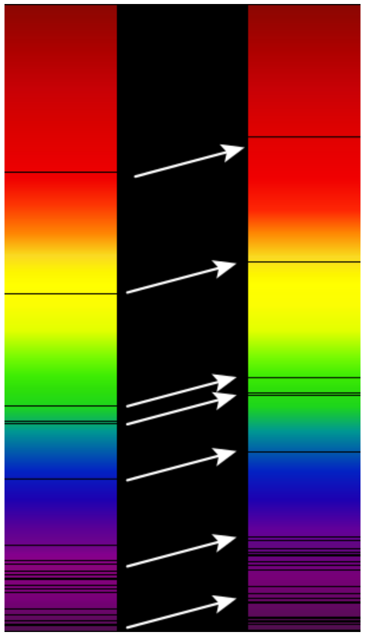
Redshift: $z = \frac{\lambda_o}{\lambda_e} - 1$

Where,
λ_o = observed wavelength
λ_e = emission wavelength

Redshift

- When an object is moving away the light increases in wavelength
- Hot objects, like stars also emit radiation (light) at specific wavelengths, known as **emission lines**; and obstruct light at specific wavelengths, known as **absorption lines**
- These lines also move to the longer wavelength part of the spectrum – they **shift** to the **red**





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