ROYAL OBSERVATORY GREENWICH

Hubble's Law

Post-16

Topics covered: Doppler effect, velocity, distance, Hubble's constant, cosmological units

Watch the video "How big is the Universe?"
https://vimeo.com/88899162

Hubble's law states that the recessional velocity of a distant galaxy, v (km s^{-1}) is linearly proportional to its distance from us, d (megaparsecs, Mpc) where the constant of proportionality is called the Hubble constant, H_0. The current value for H_0 is 67.8 km s^{-1} Mpc^{-1}.

$$v = H_0 d \qquad (1)$$

The recessional velocity of a galaxy can be found from the Doppler effect of light – comparison of the wavelengths of hydrogen emission lines from the galaxy and from a laboratory sample allow this to be calculated:

$$\frac{v}{c} = \frac{\lambda - \lambda_0}{\lambda_0} \qquad (2)$$

where v is the recessional velocity of the galaxy, c is the speed of light = 3×10^5 km s^{-1}, λ is the observed wavelength of a hydrogen emission line from the galaxy and λ_0 is the rest wavelength of the same hydrogen emission line in the laboratory.

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1. A quasar (very luminous, very distant galaxy with an active central black hole) has a hydrogen alpha emission line at 791.4 nanometres (nm). Using equation (2), calculate the recessional velocity of the quasar in **km s^{-1}**. The rest wavelength of the same line is 656.3 nm.

2. Use Hubble's Law - equation (1) to estimate the distance of this quasar. Give your answer in units of megaparsecs (Mpc) and convert this into light-years (ly), where 1 megaparsec = 3.26 x 10^6 ly.

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Hubble's Law: ANSWERS

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1. Velocity = 61755 km s^{-1}
2. 882 Mpc = 2.88 billion ly (our nearest galaxy Andromeda is over a 1000 times closer to us