Stars and Galaxies

Coursework Sheet 9 – Feedback

1. Redshift is given by

$$z = \frac{\lambda_{obs} - \lambda_0}{\lambda_0}$$

$$= \frac{656 - 486}{486} \qquad \text{(1 mark)}$$

$$= 0.35$$

Radial or recessional velocity of the galaxy is given by

$$v = cz = 0.35 \times 3.0 \times 10^8 = 1.0 \times 10^8 \text{ m s}^{-1} = 1.0 \times 10^5 \text{ km s}^{-1} \qquad \text{(2 marks)}$$

2. Distance is given by

$$d = \frac{v}{H} = \frac{1.0 \times 10^5}{71} = 1500 \text{ Mpc} \qquad \text{(2 marks)}$$

Look-back time is given by

$$t = \frac{d}{c} = \frac{1500 \times 10^6 \times 3.1 \times 10^{16}}{3.0 \times 10^8} = 1.5 \times 10^{17} \text{ s} = 5 \times 10^9 \text{ years} \qquad \text{(1 mark)}$$

(Note 5 billion years is same as the age of the Sun.)

3. An estimate of the typical peculiar velocity of a galaxy in a cluster comes from equating the kinetic energy with the gravitational potential energy and is given by

$$v \approx \sqrt{\frac{2GM}{R}} \qquad \text{(1 mark)}$$

$$= \sqrt{\frac{2 \times 6.7 \times 10^{-11} \times 10^{14} \times 2 \times 10^{30}}{2 \times 10^6 \times 3.1 \times 10^{16}}}$$

$$= 6.6 \times 10^5 \text{ m s}^{-1}$$

$$= 660 \text{ km s}^{-1} \qquad \text{(1 mark)}$$

This peculiar velocity is only 0.7% of the recessional velocity and therefore will only result in a 0.7% error in the distance which is negligible.   (1 mark)

Hence, peculiar velocities only cause large errors in the distances to nearby galaxies in clusters.   (1 mark)