Stars and Galaxies

Coursework Sheet 6 - Feedback

1. A star like the Sun which has an intrinsic colour of B-V=+0.6 is observed to have a colour B-V=+1.5 and an apparent magnitude m_V=23.5. What is the visual extinction to this object and how far away in the Galaxy is it assuming the absolute magnitude of the Sun is M_V=+4.8.

The star appears redder due to interstellar reddening and the colour excess is given by

$E(B-V)=(B-V)_{observed}-(B-V)_{intrinsic}$
$= 1.5-0.6=0.9$ (1 mark)

Total visual extinction is given by

$A_V \sim 3E(B-V)$
$= 3 \times 0.9 = 2.7$ magnitudes (1 mark)

Distance is obtained from the equation

$m_V - M_V = 5\log d - 5 + A_V$ (1 mark)

$5\log d = m_V - M_V + 5 - A_V = 23.5 - 4.8 + 5 - 2.7 = 21$

$d = 10^{21/5} = 15\ 800$ pc =15.8 kpc (2 marks)

Remember distance has to be in parsecs in this equation. Note this distance is on the far side of our Galaxy.

2. A region of our Galaxy has A_V=10. How many times fainter in the V-band are the objects here than they would otherwise be if there was no extinction? The extinction in the K-band in the near-infrared at a wavelength of 2 microns is only 1/8th of what it is at V. How many times fainter are they at this waveband.

Use Pogson's relation to relate a difference in magnitudes to a factor in brightness

$$A_V = 2.5\log\left(\frac{f_{\text{intrinsic}}}{f_{\text{observed}}}\right)$$

$$\log\left(\frac{f_{\text{intrinsic}}}{f_{\text{observed}}}\right) = \frac{10}{2.5} = 4$$ (1 mark)

$$\frac{f_{\text{intrinsic}}}{f_{\text{observed}}} = 10^4$$

i.e. the object is 10 000 times fainter than it would have been if the dust was not obscuring the object.

$$A_K \approx \frac{1}{8}A_V = \frac{10}{8} = 1.25$$

Therefore in K - band

$$\log\left(\frac{f_{\text{intrinsic}}}{f_{\text{observed}}}\right) = \frac{1.25}{2.5} = 0.5$$ (1 mark)

$$\frac{f_{\text{intrinsic}}}{f_{\text{observed}}} = 10^{0.5} = 3.2$$

i.e. the object is only about 3 times fainter than it would have been at near-infrared wavebands.

3. The mass density of the dust component within the ISM is 1% that of the total for the gas and the dust, i.e.

$\rho_{Dust} = 0.01\rho_{ISM} = 2\times10^{-23}\ \text{kg m}^{-3}$ (1 mark)

This mass density of dust is made up individual grains each of which have a mass of

$$m_{grain} = \rho_{grain}V = \rho_{grain}\frac{4}{3}\pi R_{grain}^3$$

(1 mark)

$$= 3\times10^3\times\frac{4}{3}\pi\left(0.05\times10^{-6}\right)^3 = 2\times10^{-18}\ \text{kg}$$

The mass density of interstellar dust can then be written as

$$\rho_{Dust} = n_d m_{grain}$$

$\therefore$ (1 mark)

$$n_d = \frac{\rho_{Dust}}{m_{grain}} = \frac{2\times10^{-23}}{2\times10^{-18}} = 10^{-5}\ \text{m}^{-3}$$

This can be compared to the number density of gas particles – let us assume pure hydrogen so that

$$n_{gas} = \frac{\rho_{gas}}{m_{gas}} = \frac{2\times10^{-21}}{2\times10^{-27}} = 10^{6}\ \text{m}^{-3}$$

Hence, there is only about one dust grain for every 10^{11} gas particles.