Diploma in Astronomy—First Term 2005-6

DP11 Foundations of Astronomy: Problem Paper 1. Model Solutions

8th November 2005

Solutions were to be returned by Tuesday 8 November. After that date they can be accepted, but once model solutions are posted, they cannot receive credit for marks (but can count towards completion of the course). The weighting for each question is given in ().

1) A new "dwarf" galaxy has been discovered. The new galaxy is located 10 Mpc away from us, and has an angular diameter of 200 arcseconds. What is the physical diameter of this galaxy in parsecs (pc)? in kilometres (km)? How many years does it take light to reach us from the galaxy? (10 marks)

Answer: The distance $D = \frac{\alpha d}{206{,}265} = \frac{200 \text{ arcseconds} \times 10 \text{ Mpc}}{206{,}265} = \frac{200 \text{ arcseconds} \times 10^7 \text{ pc}}{206{,}265} = 9696 \text{ pc}$

$9696 \text{ pc} = 9696 \text{ pc} \times \frac{3.0857 \times 10^{13} \text{ km}}{1 \text{ pc}} = 2.99 \times 10^{17} \text{ km}$

$1 \text{ pc} = 3.2616 \text{ ly}$ so $10 \text{ Mpc} \times \frac{10^6 \text{ pc}}{1 \text{ Mpc}} \times \frac{3.2616 \text{ ly}}{1 \text{ pc}} = 3.2616 \times 10^7 \text{ ly}$
so it takes light $\sim$32.6 million years to reach us from this galaxy.

2) A certain star has a peak intensity of its light at $\lambda_{\text{max}} = 200$ nm. What wavelength region does this correspond to? What frequency (ν) does this wavelength (λ) correspond to? What is the temperature of this star (in kelvins)? How many times brighter (or fainter) is this star than our sun? (10 marks)

Answer: From Figure 5-7 in the book, we see that 200 nm is in the Ultra-violet (UV) portion of the electromagnetic spectrum.

first change 200 nm to meters $\rightarrow 200 \text{ nm} \times \frac{1\text{m}}{10^9\text{nm}} = 2 \times 10^{-7}\text{m}$

$\lambda_{\text{max}} = \frac{0.029\text{K}\cdot\text{m}}{T} \longrightarrow T = \frac{0.029\text{K}\cdot\text{m}}{\lambda_{\text{max}}} = \frac{0.029\text{K}\cdot\text{m}}{2\times10^{-7}\text{m}} = 14,500\text{K}$

$\nu = \frac{c}{\lambda} = \frac{3\times10^8\text{m/s}}{2\times10^{-7}\text{m}} = 1.5 \times 10^{15}\text{Hz}$

$F = \sigma T^4$ so $\longrightarrow \frac{F_{\text{star}}}{F_{\text{sun}}} = \frac{\sigma T^4_{\text{star}}}{\sigma T^4_{\text{sun}}} = \frac{14500^4}{5800^4} = 39$

so, even if the star is less than 3 times hotter than the sun, it is 39 times brighter!