Tutor Marked Assignment

Course and assignment number:
S281 04

Make sure you know how to complete and send in your TMA and PT3 form: detailed instructions are given in your student handbook (or supplement).

Covering: **Block 3 and Block 4 Chapter 1**
Cut-off date:
Friday 15 September 1995

This is the final TMA and it is important that your tutor feeds your marks into the computer shortly after the cut-off date to meet exam board deadlines. Therefore, extensions beyond the cut-off date can be granted only in extreme circumstances.

This TMA relates mainly to Block 3 and Block 4 (Chapter 1), but you will need to draw on material from earlier Blocks as well.

Question 1

This question relates to Book 3 Chapter 1, and carries 22% of the marks for this assignment.

(a) (*8 marks*) In about 100–200 words, describe how the amount of *mass* in the stars and of the *mass* in the gas in the Galaxy (our galaxy) is divided between: the halo, the disc, the spiral arms, the nuclear bulge, globular clusters. *NB: This is a question about mass, not about population types.* Assuming that the mass distribution in the Galaxy is roughly spherically symmetrical, *name* the presumed component of the Galaxy that would be responsible for this symmetry.

(b) (*7 marks*) Write down (in words) the definition of the expression $M(r)$ introduced in Subsection 1.2.5 of Book 3. Draw a neat, qualitative sketch (i.e. no numbers) of $M(r)$ versus r for a case when all the mass in a galaxy is confined within a radius r_{max} of the centre, the material gradually thinning out as r_{max} is approached. Extend your graph beyond r_{max}.

(c) (i) (*5 marks*) Figure 1.11 on p. 16 of Book 3 shows the rotation curve of our galaxy. Show that, at $r > 13$ kpc, $M(r)$ is given by

$$M(r) = (8.3 \times 10^{20}\ \text{kg}) \times (r/\text{m})$$

[Hint: Equation 1.11 (also ITQ 1.2). For the manipulation of units, SAQs 1.4–1.6 in *Preparatory science* provides useful revision.]

(ii) (*2 marks*) Given that, at $r > 13$ kpc, the variation of density with distance is given by

$$\rho = k/(4\pi r^2)$$

(a proof of this is given at the end of this TMA), comment on whether Figure 1.11 shows any evidence that the matter in our galaxy is thinning out at $r > 13$ kpc.

Question 2

This question relates to Book 3 Chapter 2, and carries 26% of the marks for this assignment.

(a) (*9 marks*) Figure 1 shows photographs of three galaxies. Classify each according to the Hubble classification. Justify your classifications. *Even if you are slightly wrong, marks are available for a well-argued case.*

(b) (*8 marks*) Summarize how the following properties of galaxies vary from one Hubble class to another: (i) the diameter; (ii) the mass.

In each case, what bearing do the data have on the question of whether a galaxy can evolve from one Hubble class to another? About 150 words overall should suffice for part (b).

(c) (*9 marks*) Suppose that a spiral galaxy is discovered to have a classical Cepheid variable with a period of 27 days. The peak flux density, F_V, received on Earth in the V band from the Cepheid is 3.1×10^{-19} W m^{-2} (not a lot!). The angular diameter of the disc of the galaxy is 0.002 41 radian (8.28 arcmin – about one-third of the Moon's angular diameter). Calculate

(i) the distance to the galaxy, expressing your answer in metres and in parsecs

(ii) the diameter of the disc, expressing your answer in parsecs, and as a multiple of the Milky Way's disc diameter.

Assume negligible interstellar extinction in the V band.

We suggest that you proceed in the following steps;

- obtain M_V for the Cepheid;
- calculate L_V for the Cepheid, using the following relationship between absolute visual magnitude M_V and luminosity in the V band L_V:

  $$L_V/\text{watts} = (3.83 \times 10^{27}) \times 10^{-0.4M_V}$$

- use L_V and F_V to calculate the Cepheid's distance (Book 1, Subsection 2.3.4), and hence obtain the galaxy's distance;
- calculate the diameter of the galaxy from its distance and its angular diameter.