

Tutor Marked Assignment

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 13 September 1996

Question 1

This question relates to Book 3, Chapter 1, and Sections 2.1 and 2.2 of Chapter 2. It carries 20% of the marks for this assignment.

- (a) (8 marks) What are the features and physical properties of an elliptical galaxy that distinguish it from other types of galaxy? (5 or 6 sentences should suffice.)
- (b) (8 marks) What is the evidence that the Milky Way is *not* an elliptical galaxy? (5 or 6 sentences should suffice.)
- (c) (4 marks) What is the additional evidence that it is a typical spiral galaxy? (3 or 4 sentences should suffice.)

Question 2

This question relates to Book 3, Chapters 2 and 3, and carries 25% of the marks for this assignment.

- (a) (9 marks) A recently discovered galaxy emits an optical spectrum with a spectral flux density F_λ that peaks at a wavelength of 400 nm. It is the most distant known galaxy, with a redshift of 4. At what wavelength is this peak observed by an observer on Earth? In what part of the spectrum is this? Can it be observed by an astronomer on Earth, or does it require a satellite-borne telescope?
- (b) (8 marks) Compare the spectrum emitted by this galaxy, and its luminosity, with that of a normal galaxy, and explain as fully as you can any differences. (50 words should suffice.)
- (c) (8 marks) Why could a starburst galaxy look rather like this galaxy? How would the observer distinguish between this galaxy and a starburst galaxy? (A few sentences should be sufficient.)

Question 3

This question relates to Book 3, Chapter 3, and carries 25% of the marks for this assignment.

Recent evidence suggests that a broad spectral line observed from an active galactic nucleus at X-ray wavelengths originates in the accretion disc close to the Schwarzschild radius. This question leads you through a calculation of the broadening that might be expected if the line was from such a site.

- (a) (5 marks) Calculate the Schwarzschild radius, R_s , for a black hole of mass $2 \times 10^8 M_\odot$. Show your working.
- (b) (7 marks) Consider some material orbiting in the accretion disc at a radius of $8R_s$. Using the equation from Chapter 1 that relates mass inside a radius to radius and rotational speed, show that at $8R_s$ the material moves with a speed close to $v = c/4$.
- (c) (6 marks) As this material orbits (at speed!) in the disc, the emitted X-ray emission is Doppler-shifted. Sketch the black hole and disc, marking on the direction of rotation. What way should the disc be orientated to give maximum Doppler shifts from this material? From which part of the disc do you see maximum blueshift? From which part maximum redshift? (Neglect any relativistic effects.)
- (d) (7 marks) What Doppler broadening would you expect in total from the material at $8R_s$, assuming that no telescope can separately resolve the sites of maximum redshift and maximum blueshift? Express this broadening in terms of the unshifted wavelength of the line (λ), and show your working. [Your calculation will, because of the neglect of relativistic effects, be a crude one. Nonetheless you might be interested, having done the calculation, to look at the item in the *Yearbook* on MCG-6-30-15. It is not necessary to do this as part of your answer, however.]

$$z = \frac{\lambda_o - \lambda_e}{\lambda_e} = 4$$

$$4 = \frac{400 - \lambda_e}{\lambda_e}$$

$$4 = \frac{\lambda_o - \lambda_e}{\lambda_e}$$

$$4 = \frac{\lambda_o}{400} - 1$$

$$\lambda_o = 2000 \text{ nm}$$

$$= 2 \times 10^{-6} \text{ m}$$