Physics of Galaxies: Set 8

Issue Date: 30/11/17 Hand-In Date: 07/12/17

Students should hand in their exercises by **4.00pm** on the date given above; exercises will not be accepted for marking later than this. The **Course Title**, the exercise **Set Number** and the **Student's Name** should be stated clearly.

1. The luminosity of an annulus of an accretion disk, which extends from *r* to *r+dr* in an AGN is given by the blackbody Planck's formula

$$L_\nu \propto \nu^3 \int_{r_{lso}}^{r_{max}} \frac{rdr}{e^{h\nu/kT(r)}-1},$$

where r_{lso} and r_{max} are the inner and outer edges of the accretion disc, in three different limits $\frac{h\nu}{kT} << 1$, $\frac{h\nu}{kT} \sim 1$, $\frac{h\nu}{kT} >> 1$, to show that the AGN spectrum in the corresponding three ranges is proportional to $\nu^2, \nu^{1/3}, \nu^3 \exp(-h\nu / kT_{lso})$, respectively.

[9 marks]

2. Observations of the energy spectrum of cosmic ray electrons arriving at the Earth suggest that the electrons responsible for the synchrotron radio spectrum from radio jets might have the same range of relativistic energies. What is the relativistic factor γ for an electron with energy E and rest mass m_e? Express this in terms of β =v/c, where v is the speed of the electron. Also obtain an expression for β in terms of γ and use this to derive an approximation for β when γ is large, keeping only terms up to order $1/\gamma^2$. **[5 marks]**
For electrons with energies E = 10, 100, 1000, 10000 MeV, use your expressions to construct a table whose columns give the values of E (in MeV), γ, β and 1-β. **[5 marks]** (In finding β and 1-β you may find some difficulty displaying the answer if your calculator does not have the accuracy to display all the significant figures. Decide how to display the information and remember the possibility of using exponential notation.)
What do you conclude from your values of β regarding the approximation one might use in expressions containing factors of β in Chapter 4 of the notes? [**2 marks]**

21 marks in total