Physics of Galaxies Exercise 9

1. The power of synchrotron emitting AGN radio source is $-\frac{dE(t)}{dt} = P(E) = bB^2E^2$ and the frequency of the synchrotron radiation maximal power is given by $\nu = aBE^2$.
Show that the timescale over which the source loses half of its initial energy is given by $\tau(E) = \frac{a^{1/2}}{b} B^{-3/2}\nu^{-1/2}$.

[8 marks]

2. Describe the general physical process that gives rise to *synchrotron radiation*.

[2 marks]

Over a wide range of frequencies the radio continuum spectrum of many radio galaxies can be approximated by a power law $S_\nu \propto \nu^\alpha$ where S_ν is the flux density at radiation frequency ν and $\alpha \approx -0.75$. Show that this is consistent with the observed emission being synchrotron radiation from a population of relativistic electrons with a power law energy distribution

$$N(E)dE \propto E^{-p}dE$$

where $p \approx 2.5$. [Hint: An energetic electron with energy E in the presence of a magnetic field B radiates a power $P \propto B^2E^2$ at a frequency $\nu \propto E^2B$.] **[8 marks]**

3. An AGN emits at the Eddington luminosity limit, $L_E = 4\pi GcM_{BH}m_p/\sigma_T$, of 10^{39} W. The Thomson cross-section is $\sigma_T = \frac{8\pi}{3}\left(\frac{e^2}{4\pi\varepsilon_0 mc^2}\right)^2$. Determine the mass of the central Black Hole (BH), expressed in solar masses. **[3 marks]**

4. Assume that size of the emitting region of another AGN is roughly three Schwarzschild radii. Estimate the mass of the BH, in solar masses, if the AGN varies on the time scale of 24 hours. **[3 marks]**

In total 24 Marks available