EE356 Elementary Plasma Physics H.O. #29

Inan 10 May 2002

Spring 2002

HOMEWORK ASSIGNMENT #5
(due Monday, May 17th)

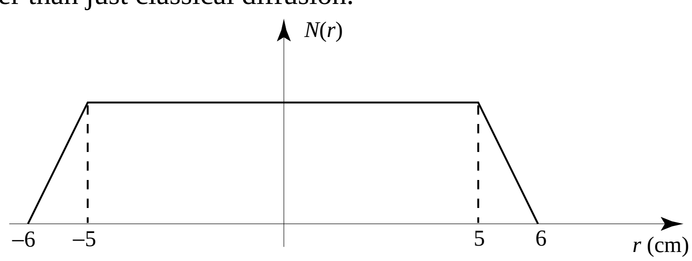
1. **Plasma resistivity.** A Tokamak is a toroidal plasma container in which a current is driven in a flully ionized plasma by an electric field applied along **B** (which is azimuthal – along the toroid). How many V/m must be applied in order to drive a total current of 200 kA in a plasma with $k_{\mathrm{B}}T$ = 500 eV and a cross-sectional area of 75 cm^2?

2. **General solution of the diffusion equaiton.** Please do Bittencourt problem 10.9, p. 264. In addition, for part (b), discuss what these integrals mean physically. For part (d) explain how varying x_0 affects the characteristic time of the diffusion process and why this happens. Note that this problem deals with the derivation of equation [14.6] of Lecture#13 Notes.

3. **Solid state plasma.** Bittencourt, p. 262, Problem 10.1.

4. **Complex conductivity.** Bittencourt, p. 263, Problem 10.4.

5. **Fusion reactor.** Suppose that the plasma in a fusion reactor is in the shape of a cylinder 1.2 m in diamater and 100 m in length. The 5 T magnetic field is uniform except for short mirror regions at the ends, which we can neglect. Other parameters are $k_{\mathrm{B}}T_i = 20$ keV, $k_{\mathrm{B}}T_e = 10$ keV, and $N = 10^{21}$ m^{-3} at r = 0. The plasma density profile is found experimentally to be as shown below. (a) Assuming classical diffusion, calculate $D_\perp$ at $r = 0.5$ m. (b) Calculate dN/dt, the total number of electron-ion pairs leaving the central region radially per second. (c) Estimate the confinement time, which you can take roughly to be $-N/(dN/dt)$. Note that an approximate estimate is all that can be expected here, since the density profile shown has obviously been determined by processes other than just classical diffusion.



6. **Bohm versus classical diffusion.** Confinement experiments performed in the 1950's showed that confinement times differed markedly from those predicted by the classical diffusion theory. A semi-empirical formula derived by David Bohm (in work which began at UC Berkeley as a graduate student) shows a much better agreement with experiments and has proved successful in a surprisingly large number of instances. Read Bittencourt p.261 (bottom half of the page) - 262 and answer the following question:

   A cylindrical,fully ionised, plasma column has a density distribution:

   $$n = n_0(1 - r^2/a^2)$$

   where $a = 10$ cm, and $n_0 = 10^{19}$ m^{-3}. If $k_{\mathrm{B}}T_e$=100 eV, $k_{\mathrm{B}}T_i$=0, and the axial magnetic field B_0 is 1 T, what is the value of the Bohm and classical diffusion coefficients? What is the ratio between these 2 quantities? What do these results imply about the diffusion time and subsequent loss-rate from the plasma column?