

Introduction to Plasma Physics (PY5012) Homework 1

Submit solutions at lecture on Monday, October 10, 2011

Note: This homework is worth 10% of total module mark

1. State and describe the three criteria required for an ionised gas to be considered a plasma (<1 page).

2. Compute the Larmor radius for the following cases, assuming $v_{||}$ is negligible.
 - a) A 10 keV electron in the Earth magnetic field of 5×10^{-5} T.
 - b) A solar wind proton with streaming velocity of 300 km s^{-1} along a magnetic field of 5×10^{-9} T.
 - c) A 1 keV He^+ ion in the solar atmosphere near a sunspot, where the magnetic field is 5×10^{-2} T.

3. a) Assuming a slab of plasma of cross-section A and thickness dx , containing n_n neutral particles per unit volume with cross-sections σ , show that the flux of an incident beam of electrons varies as

$$\Phi = \Phi_0 e^{-x/\lambda_{mfp}}$$

where $\lambda_{mfp} = 1/(n_n \sigma)$ is the mean free path.

- b) The Coulomb cross-section of a charged particle can be written $\sigma = \pi r_c^2$, where r_c is a measure of the Coulomb radius. Taking into account that the Coulomb potential is approximately equal to the electron thermal energy at r_c , show that

$$\sigma = \pi \left(\frac{e^2}{6\pi k_B \epsilon_0} \right)^2 \frac{1}{T^2}$$

- c) Discuss the terms *collisional* and *collisionless* plasmas, making particular reference to the mean free path and Coulomb cross-section.