Plasma Physics for Fusion - Assignment 2

(a) Describe the physics behind the Langmuir (or electron plasma) wave, using figures as appropriate to illustrate your description. Include a discussion of why finite temperature is required for the wave to transfer information (i.e. have non-zero group velocity)

(20%)

(b) Write down the plasma fluid equations that describe the following: (i) the electron force balance; (ii) electron continuity, and (iii) Poisson's equation. These equations relate the flow, density, electric field and magnetic field. Describe the physics of each equation, including a careful definition of what is meant by the convective derivative.

(20%)

(c) Consider a homogeneous, cold magnetised plasma equilibrium in which there is no flow and no electric field. [*Hint: for a cold plasma you can neglect the pressure gradient, but because this is a magnetised plasma you must include the magnetic field (unlike the situation we considered in the lectures)*]

(i) Show that this equilibrium satisfies the equations you wrote down in part (b) provided it is quasi-neutral.

(10%)

(ii) Assuming the equilibrium magnetic field is in the z-direction, consider small perturbations of the equilibrium quantities with a temporal and spatial dependence of the form $e^{-i(\omega t - kx)}$ (i.e. no dependence on y or z) to derive expressions for the x and y components of the perturbed flow, the perturbed electron density and the x component of the perturbed electric field. You may assume that the ion density perturbations are negligible and adopt the linear approximation.

(30%)

(iii) Solve your linearised equations to show that the frequency of oscillations can be written in the form

$$\omega^2 = \omega_{pe}^2 + \omega_{ce}^2$$

and give expressions for ω_{pe} and ω_{ce}.

(20%)