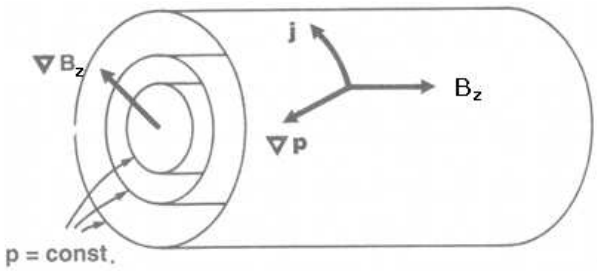
Introduction to Plasma Physics (409.307A)

Final Examination

18 June, 2019

1. Answer the following questions for the magnetic fusion device shown below.



(1) (10 points) In this system, a plasma current j is self-generated. Calculate this current in view of equilibrium.

(2) (10 points) In a fluid approach, the diamagnetic drift exists if there is a pressure gradient in the plasma as $\overrightarrow{v_D} = -\frac{\nabla p \times \vec{B}}{qnB^2}$.
Discuss the relation of this drift motion and the plasma current calculated in (1).

(3) (25 points) We operate the magnetic fusion device shown in the figure above by the following procedure; i) breakdown, ii) apply magnetic field, iii) increase the temperature by heating to fully ionise the plasma for fusion reactions. Discuss how the plasma diffusion changes in each procedure in terms of collisionality, temperature, characteristic length (Δx) & time (Δt), respectively.
Note, $D = \frac{\Delta x^2}{\Delta t}$

(4) (10 points) If this cylindrical device is modified to a torus, discuss how the diffusion changes in the fully ionised phase.

2. Answer the following questions.

(1) (10 points) Derive the plasma frequency (ω_p) of the plasma oscillation using the fluid equations shown below assuming that the electron temperature is negligible.

$$mn_e\left[\frac{\partial \vec{v_e}}{\partial t}+\left(\vec{v_e}\cdot\nabla\right)\vec{v_e}\right]=-en_e\vec{E}$$

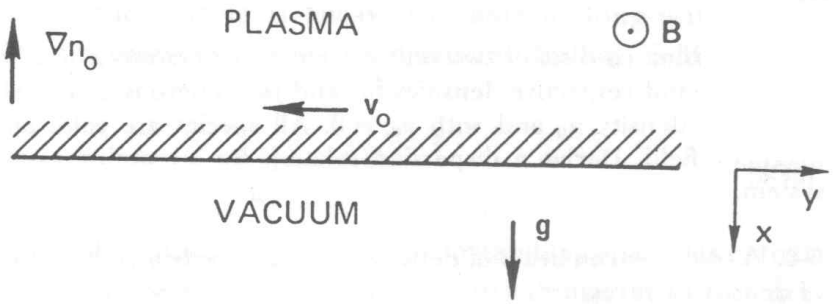
$$\frac{\partial n_e}{\partial t}+\nabla\cdot\left(n_e\vec{v_e}\right)=0$$

$$\epsilon_0\nabla\cdot\vec{E}=e\left(n_i-n_e\right)$$

(2) (10 points) Explain the physical reason for the generation of plasma oscillations.

(3) (15 points) If the electron temperature is not zero and there is a density gradient, derive the dispersion relation and describe how this wave propagates.

3. (10 points) Describe a possible instability which can arise in the plasma below.



한 학기 동안 모두들 수고 많으셨습니다. 좋은 결과 얻으시길 바랍니다.

"Look at the birds of the air; they do not sow or reap or store away in barns, and yet your heavenly Father feeds them. Are you not much more valuable than they?" (Mathew 6:26)