SEMINAR FYS 3610 WEEK 39

Reading Task 1:
Read K&R Chapter 11 and prove that the roots of the dispersion relation give by Equation 11.20 is given as 11.20a and 11.20b.
Point out which solution is the Shear Alfven mode, which one is the Slow mode and which one is the Fast mode.
Discuss Figure 11.3

Reading Task 2:
Read K&R 11.6. Consider the box model, and derive Equation 11.21.

EXERCISE 1:

a) What do we mean by cold plasma approximation? Write up the MHD equations for a cold plasma approximation and linearize them.

b) Eqs. 11.18 a and 11.18b give the roots of the dispersion relation for cold plasma. Show that Eq. 11.18b implies : $\left|\vec{B}_0 + \vec{B}_1\right| = B_0^2 + 2\frac{k}{\omega}u_{1x}B_0^2$. Comment why we call this wave solution the compressional mode.

c) Study Figure 11. 2.

EXERCISE 2

From the Maxwell's equations we have

$$\nabla \times \vec{E} = -\frac{\partial \vec{B}}{\partial t} \qquad (2.1)$$

$$\nabla \cdot \vec{B} = 0 \qquad (2.2)$$

$$\nabla \times \vec{B} = \mu_0 \vec{j} \qquad (2.3)$$

and the generalised Ohm's law is given by

$$\vec{j} = \sigma(\vec{E} + \vec{v} \times \vec{B}) \qquad (2.4)$$

a) Show that the time varying magnetic field can be expressed as

$$\frac{\partial \vec{B}}{\partial t} = \frac{1}{\mu_0 \sigma} \nabla^2 \vec{B} + \nabla \times (\vec{v} \times \vec{B}) \qquad (2.5)$$

(Hint: $\nabla \times (\nabla \times \vec{B}) = \nabla(\nabla \cdot \vec{B}) - \nabla^2 \vec{B}$)

b) Infer the magnetic Reynolds number (R_m) by taking the ratio of the second term to the first term on the right hand side of Equation 2.5. Use L as a characteristic scale length for changes of the field and flow.

c) Discuss the usage of the Reynolds number as an indicator of whether the frozen-in-flux concept is valid or not. Why does the frozen-in-flux concept (ideal MHD) break down locally near a reconnection site.