PHY 525 Homework 5 Due: **Thursday**, November 7, 2019

1. Strongly magnetized plasma

Consider a collisionless cold uniform plasma with an "infinitely strong" magnetic field, that is, assume that $\omega_{ce,\,ci} \gg \omega_{pe,\,pi}, \omega$. Simplify the plasma dielectric tensor ε_{ij} in this case.

a) Find the dispersion relations of the waves existing in such a plasma (consider an arbitrary propagation angle with respect to the magnetic field);
b) Find the electric field polarizations of the waves.

Does the answer depend on the magnetic field strength? Why?

2. Collisions

To consider the effect on the dispersion relation of collisions between electrons and ions, modify the electron equation of motion as follows:

$$\partial \mathbf{v}_e / \partial t + (\mathbf{v}_e \bullet \nabla)\mathbf{v}_e = (-|e|/m_e)\,\mathbf{E} - \nu \mathbf{v}_e,$$

where ν is a constant collisional frequency, and ions are stationary.

a) Show that the dispersion relation for an electromagnetic wave is

$$\frac{k^2c^2}{\omega^2} = 1 - \frac{\omega_{pe}^2}{\omega(\omega + i\nu)};$$

b) When $\nu \ll \omega$, find the damping rate of the wave $\gamma = -\mathrm{Im}(\omega)$.

3. Diffusion

A weakly ionized plasma is created in a cubical aluminum box of length L=1m on each side. It decays by ambipolar diffusion.

a) Write an expression for the density distribution in the lowest diffusion mode.
b) Define what you mean by the decay time constant and compute it if $D_a = 10^{-3}\ m^2/s$.