

Problem 1

In a partially ionized un-magnetized cold plasma both electrons and ions collide with neutrals. A simple way to account for collisions in the equation of motion of the electrons and ions is to include a drag force:

$$\mathbf{F}_s^{\mathbf{D}} = -\nu_s m_s \mathbf{v}_s , \quad (1)$$

where ν_s is the collision frequency for species s .

a) Show that the effect of collisions is to introduce a frequency dependent effective mass

$$m_s \rightarrow m_s \left(1 + \frac{i\nu_s}{\omega}\right) \quad (2)$$

b) Find the dispersion relation for longitudinal electron plasma oscillations and identify the effects of collisions.

c) Show that for transverse waves in the high-frequency limit ($\nu_s \ll \omega$ and $\omega_p \ll \omega$)

$$k = \frac{\omega}{c} \left(1 - \frac{\omega_p^2}{2\omega^2}\right) + i \frac{1}{2c} \sum_s \frac{\nu_s \omega_{ps}^2}{\omega^2} \quad (3)$$