PHY 525 Homework 3 Due: **Tuesday, Oct. 15**, 2019

1. Plasma Frequency

In the derivation of the plasma frequency, suppose the ions are not infinitely massive but have mass m_i . Modify the discussion given in the class and derive the total plasma frequency.

2. Langmuir waves

Electron plasma waves are propagated in a uniform plasma with kT_e=100eV, n=10^{16} m^{-3}, B=0. If the frequency f is 1.1GHz, what is the wavelength in cm?

3. Ion-acoustic waves

Derive the dispersion relation ω(k) for the ion waves in a uniform non-magnetized plasma in the region $k \gg \omega_{pe}/v_{Te}$, taking into account ion thermal motion. Explain the analogy with the electron plasma waves.

4. Dispersion of radio waves

Radio signals from pulsars pass through the interstellar medium that contains free electrons.

(a) Show that the arrival time t(f) of a signal will be a function of frequency of the form

$$t(f)=Df^{-2} + \text{const},$$

where f is frequency in Hz, and the ``dispersion coefficient'' D is expressible as

$$D=C \int n_e \, ds,$$

where the integral represents the integral of the electron density along the propagation path of the radio signals.

(b) Find the coefficient C.
(c) For a particular pulsar it is found that the signal at 100MHz arrives 2s later than the signal at 200MHz. What is the value of D for that pulsar?
(d) If the mean electron density is 0.03 cm^{-3}, estimate the distance to the pulsar in centimeters.