AS551 General Plasma Physics 1
September 20, 1996

**Problem Set #2 (due September 27)**

1. Since much of the galaxy is filled with an electron-proton plasma, one might expect that the propagation of starlight reaching the earth could be affected. Calculate the dispersion relation for plane electromagnetic waves in this plasma, by modeling the plasma as a uniform cold electron fluid. If the electron density were 1 $\mathrm{cm}^{-3}$, what restriction is based on the observation of radio wave signals? What effect would the inclusion of electron pressure have? What other effects might have to be included to obtain a realistic description of the propagation of light in the inter-stellar plasma.

2. In class, we derived the Debye shielding of the potential produced by a test charge $Q$ in a plasma. Calculate the resulting electron density and verify than the test charge is indeed shielded by showing that the total excess electon charge is $-Q$. [Something to think about: Suppose the test charge is *moving*. How do you expect the Debye shielding to change?]

3. Assuming that the collision cross section is the square of the distance of closest approach, derive the $v^{-3}$ dependence for the collision frequency of electrons streaming through a field of stationary ions. [Later in the course, we shall see this assumption underestimates the collision frequency by about $\log(n\lambda_D^3)$. The scaling is, however, correctly given.]

4. Consider a homogeneous cold electron plasma, where the ions may be assumed to be an infinitely massive neutralizing background. Suppose that a small fraction of the electrons in the slab $x_1 < x < x_2$ are removed and then placed at $x_1 + L < x < x_2 + L$. Sketch the subsequent evolution of the electron density, the electric field, and the electron fluid velocity. Sketch the trajectory of a single electron.