NE 795 Assignment 1

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Question 1 Plasma Conditions

1(a) Conditions List the three conditions that describe the plasma state.

1(b) Evaluate these conditions for the following systems given the electron density (n_e), electron temperature (T_e) and plasma-neutral collision time (τ):

- The ionosphere ($n_\mathrm{e} = 1 \cdot 10^{12}$ m^{-3}, $T_\mathrm{e} = 0.1$ eV, $\tau = 1 \cdot 10^{-5}$ s)
- A candle flame ($n_\mathrm{e} = 1 \cdot 10^{14}$ m^{-3}, $T_\mathrm{e} = 0.1$ eV, $\tau = 1 \cdot 10^{-10}$ s)

Where

$$\sqrt{\frac{\mathrm{e}^2}{\epsilon_0 m_\mathrm{e}}} = 56.41 \text{ m}^{3/2}\text{s}^{-}1$$

$$\sqrt{\frac{\epsilon_0}{\mathrm{e}^2}} = 7433.94 \text{ eV}^{-1/2}\text{m}^{-1/2}$$

with elementary charge (e) $1.602 \cdot 10^{-19}$ C, electron mass (me) $9.109 \cdot 10^{-31}$ kg and vacuum permittivity (ϵ_0) $8.854 \cdot 10^{-12}$ Fm-1

1(c) Conclude for both systems if they are a plasma (or not) and provide a reasoning for your conclusion.

Question 2 Debye Length

Consider two infinite, parallel plates located at x = -d and x = d. Both plates are kept at a potential of $\Phi = 0$V. The space between the plates is uniformly filled with a gas at density N

of particles with charge q (note this is not a plasma, all the particles have the same charge).

2(a) Using Poisson's equation, show that the potential distribution between the plates is given by the equation:

$$\Phi(x) = \frac{Nq}{2\epsilon_0}(d^2 - x^2)$$

2(b) The Debye length λ_D describes the scale length at which the balance between electrostatic potential energy and thermal kinetic energy is established in a plasma. Show that for $d > \lambda_D$ the electrostatic potential energy needed to transport a particle from one of the plates to the midpoint at $x = 0$ exceeds the average thermal kinetic energy of particles in a one-dimensional system. Assume a one-dimensional Maxwellian distribution with $< E_{kinetic} >= \frac{1}{2}k_B T$

References