HW1 of Plasma

Chen Tang

1. according to the pressure formular:

$$P = n \cdot k_B (T_i + T_e)$$, insert into with

$n = 10^{14}\ cm^{-3} = 10^{8}\ m^{-3}$,

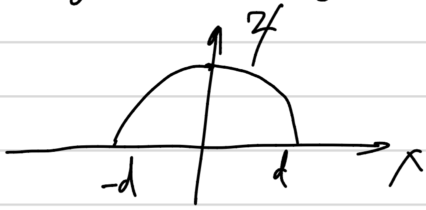
$k_B T_i = k_B T_e = 20 keV = 20 \times 10^{3} \times 1.602 \times 10^{-19} = 3.204 \times 10^{-15}$

so $P = 3.204 \times 10^{-7}\ kg \cdot m^{-1} \cdot s^{-2}$ ($2 \times 10^{15}\ keV/cm^{3}$)

2. poisson equation : $\nabla^2 \psi = -\rho/\varepsilon_0$, apply the boundary condition and $\rho = q \cdot n$

$$\frac{d^2}{dx^2} \psi = -qn/\varepsilon_0 \text{ , and } \psi(\pm d) = 0$$

so $\psi(x) = -\frac{qn}{2\varepsilon_0}(x^2 - d^2)$ $\quad |x| \le d$



3. given (2.2.10) , debye length $\lambda_D = 6.9 \sqrt{\frac{T_e}{n_0}}$ cm

particle numbers in debye sphere would be:

$$N = n_0 \cdot \frac{4\pi}{3} \lambda_D^3$$, apply all parameters.

$$N = \frac{4\pi}{3} \cdot (6.9)^3 \cdot (5 \times 10^7)^{\frac{3}{2}} \cdot (10^{27})^{-\frac{1}{2}} = 1.539 \times 10^{28}$$

4. given $P = nkT \quad P \propto n.$

also the density follows boltzmann distribution.

$n \sim \exp\left(-\frac{E}{kT}\right)$, take gravitational potential as $E = mgh$.

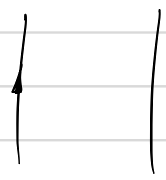
$\frac{n_{boulder}}{n_{newyork}} = \exp\left(-\frac{mg}{kT}(h_b - h_n)\right)$, google tells that $h_b - h_n = 1645\ m$.

and $m \sim 29\ g/mol$, $g = 9.8\ m/s^2$.

so $\frac{n_b}{n_n} = \exp\left(-\frac{29\times10^{-3}}{6.02\times10^{23}} \cdot \frac{9.8}{1.38\times10^{-23}} \cdot \frac{1645}{20+273.15}\right) = 0.8253$

so pressure in Boulder is 17.46% lower than in New York.

5. magnetic field around a moving particle has form of:



$B = \frac{\mu_0 q \cdot v_i}{2\pi d}$, and magnetic force has form of:

$F_B = q \cdot v_i \cdot B$, also the electrostatic force is:

$F_E = \frac{1}{4\pi\varepsilon_0} \cdot \frac{q^2}{d^2}$

so $F_B/F_E = 2 \cdot \left(\frac{v_i}{c}\right)^2 \cdot d$

non-relativistic plasma has $v_i \ll c$, and $d \ll 1$

so $\frac{F_B}{F_E} \ll 1$, electrostatic force is much stronger than Lorentz force.