Plasma parameter

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Condition for Debye shielding: Number of particles in a Debye sphere is much larger than 1.

=> Plasma parameter: $N_D \equiv 4\pi\, n\, L_D^3 \sim \frac{4\pi}{3}\, n\, L_D^3 \sim \sqrt{\frac{(k_B T)^3}{n\, e^6}} >> 1$

$\longrightarrow$ $L_D \gg n^{-1/3} = \bar{l}$ (mean interval between particles)

This condition is equivalent to each of the following conditions:

I. mean electrostatic energy << thermal energy => plasma forms a **weakly bounded system**

$$L_D^2 \sim \frac{k_B T}{e^2 n} \gg n^{-\frac{2}{3}} \Rightarrow k_B T \gg \frac{e^2}{n^{-\frac{1}{3}}} = \frac{e^2}{\bar{l}} = e\, \bar{\phi}_c$$

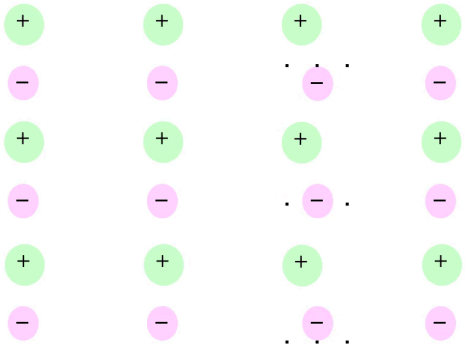
This justifies the **assumption** $e^{-\frac{e\phi_c}{k_B T_e}} \approx 1 - \frac{e\phi_c}{k_B T_e}$ that is used to derive Debye length.

II. L_D >> effective radius r_{eff}

$$\frac{L_D}{r_{eff}} \sim \frac{\sqrt{k_B T / n e^2}}{e^2 / k_B T} = \sqrt{\frac{(k_B T)^3}{n\, e^6}} \sim N_D \gg 1$$

$$r_{eff} \sim \frac{e^2}{m v^2} \sim \frac{e^2}{k_B T} = \frac{4\pi e^2 n}{k_B T} \frac{1}{4\pi n} = \frac{L_D}{N_D}$$

Plasma oscillation



When significant deviation from charge neutral state temporarily occurs in local region, ...