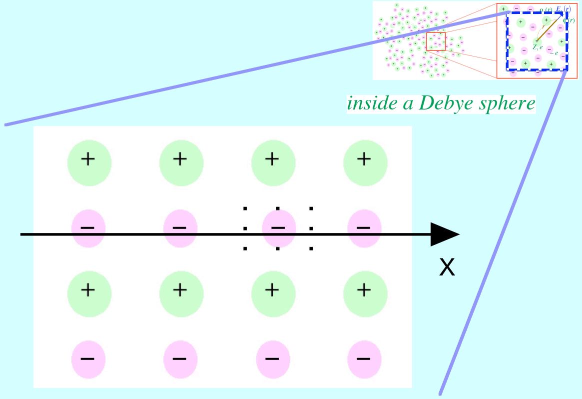
Plasma frequency

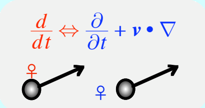


Subscript 0 indicates initial equilibrium values, while subscript 1 indicates oscillating values.

Ions are static $(n_i = n_0,\ v_{ix} = 0)$ because their mass is large.

Electrons oscillate. Electric field also oscillates.

$$n_e = n_0 + n_1(x,t) \quad v_{ex} = v_0 + v_1(x,t),\ v_0 = 0 \quad E_x = E_0 + E_1(x,t),\ E_0 = 0$$



$$\frac{\partial n_e}{\partial t} + \frac{\partial}{\partial x}(n_e\, v_{ex}) = 0$$

$$m_e\, n_e \left[\frac{\partial v_{ex}}{\partial t} + v_{ex}\frac{\partial v_{ex}}{\partial x}\right] = -e\, n_e\, E_x$$

$$\frac{\partial E_x}{\partial x} = 4\,\pi\, e\,(n_i - n_e)$$

Linearization

$$\Diamond_1\, \Delta_1 \sim 0$$

$$\Diamond_1 \propto e^{i(k_x x - \omega t)}$$

$$\frac{\partial \Diamond_1}{\partial t} \Rightarrow -i\,\omega\,\Diamond_1,\quad \frac{\partial \Diamond_1}{\partial x} \Rightarrow i\,k_x\,\Diamond_1$$

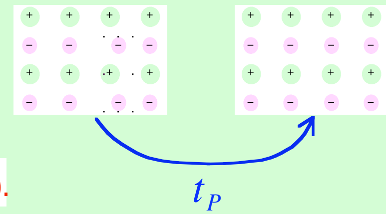
Plasma frequency:

$$\omega = \sqrt{\frac{4\pi n_0 e^2}{m_e}} \equiv \omega_p = 2\,\pi\,\nu_P$$

$$\omega_p = \sqrt{\frac{n_0 e^2}{\varepsilon_0 m_e}}\ (MKS\ unit)$$

$$t_P = \frac{1}{\nu_P} \sim \frac{L_D}{v_{Te}}$$

... Time required for an electron to relax to a neutral state via oscillation => **Neutralization time**



Charged particles feel electric field during t_P (or electric field arises during t_P).