B. Sc. (Hons)
part III

Plasma Oscillation

paper VII Group "A"

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In the analysis of the Debye screening the plasma was assumed to be in the equilibrium, that is, the plasma charges were not moving (except for the fast random motion which is averaged out). Thus, the screening is an example of the static collective behavior.

Let us assume that the plasma consists of freely moving electrons and an immobile neutralizing background. Let the charge of the electron be q, mass m, and density n.

Let us assume that, for some reason, all electrons, which were in the half-space $x > 0$, move to the distance d to the right, leaving a layer of the non-neutralized background with the charge density $\rho = -nq$ and width d.

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The electric field, produced by this layer on the electrons on both edges is

$$E = 2\pi\rho d = -2\pi nqd$$

(for the electrons at the right edge) and

$$E = 2\pi\rho d = 2\pi nqd$$ (for the electrons at the left edge.)

The force $F = qE$

$$= -2\pi nq^2 d$$

accelerates the electrons at the right edge to the left, while the electrons at the left edge experience similar acceleration on the right.

The relative acceleration of the electrons at the right and left edges would be

$$a = 2(qE/m)$$

$$= -4\pi nq^2 d/m.$$

On the other hand $a = \ddot{d}$, so that one has

$$\ddot{d} = -\omega_p^2 d$$

$$\omega_p^2 = 4\pi n q^2 / m \quad \text{——— (1)}$$

The derived equation describes oscillations with the plasma frequency ω_p. It should be emphasized that the motion is caused by the coordinated movement of many particles together and is thus a purely collective effect. In oder to be able to observe these oscillations their period should be much smaller than the typical life time of the system.

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