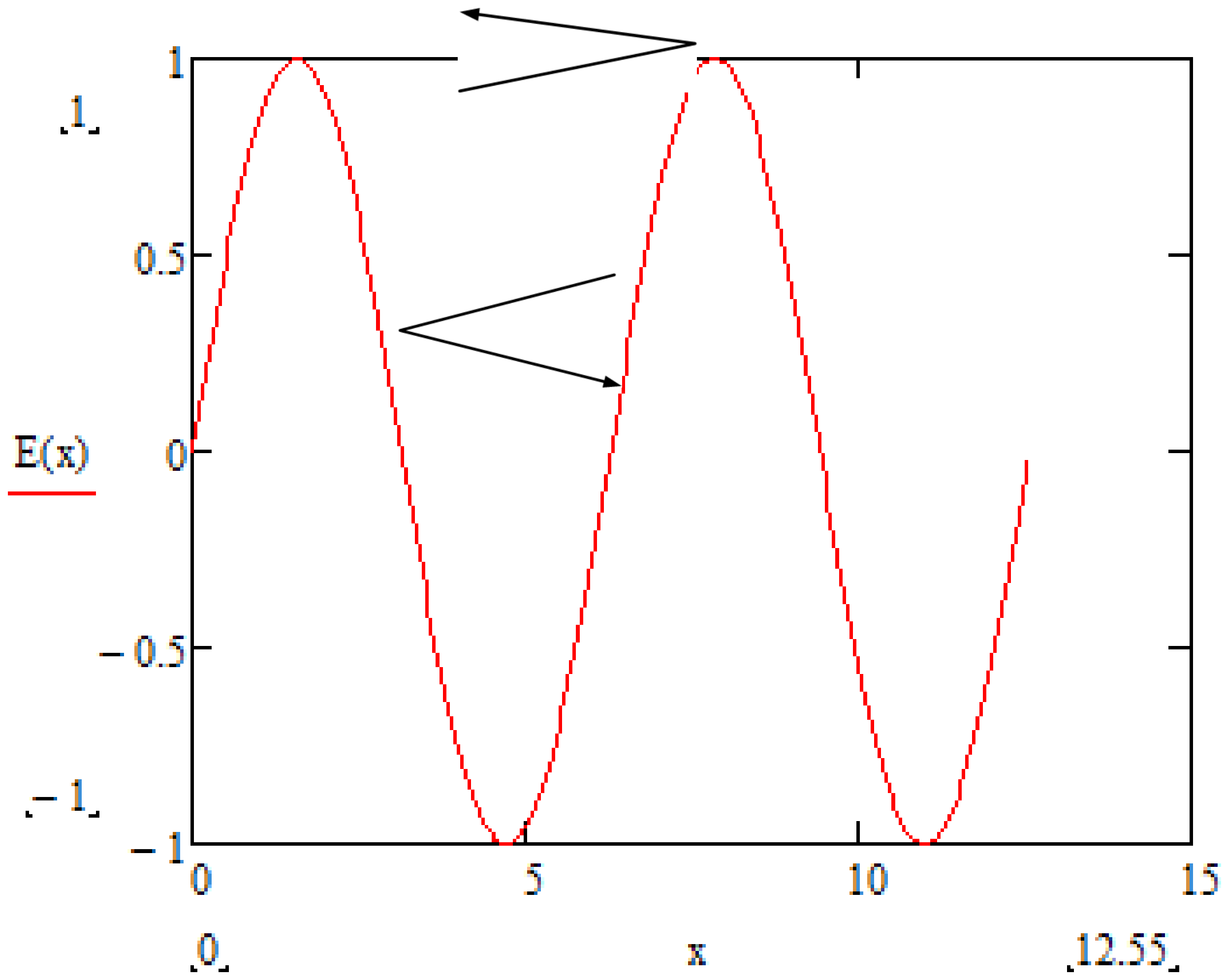
Лекция 9

Затухание Ландау



$$\frac{m\left(v - v_f\right)^2}{2} < e\Phi$$

$$E = -\left(\frac{d\Phi}{dx}\right) = k \cdot \Phi$$

$$v_{max} = v_f + \sqrt{\frac{2e \cdot \Phi}{m}} = v_f + \sqrt{\frac{2eE}{m \cdot k}}$$

$$v > v_f$$

$$\Delta W_e = \frac{mv^2}{2} - \frac{m}{2}\left(v - 2v_f\right)^2$$

$$\Delta W_e = 2m \cdot v_f \cdot \left(v - v_f\right)$$

$$N_{col} = \frac{v - v_f}{\lambda} \qquad \lambda = \frac{2 \cdot \pi}{k}$$

$$P_1 = \Delta W_e \cdot N_{col} = 2m(v - v_f)^2 \cdot v_f \cdot \lambda^{-1}$$

$$v < v_f$$

$$P_2 = 2m \cdot (v_f - v)^2 \cdot v_f \cdot \lambda^{-1}$$

$$\frac{dW}{dt} = 2m \cdot v_f \cdot \lambda^{-1} \cdot \left[\int_{v_f}^{v_f + \sqrt{\frac{2eE}{mk}}} (v - v_f)^2 \cdot f_0(v)\, dv \right]$$

$$-2m \cdot v_f \cdot \lambda^{-1} \left[\int_{v_f - \sqrt{\frac{2eE}{mk}}}^{v_f} (v - v_f)^2 \cdot f_0(v)\, dv \right]$$

$$f_0(v) = f_0(v_f) + \left(\frac{df_0}{dv}\right)_{(v_f)} \cdot (v - v_f)$$

$$\frac{dW}{dt} = \frac{2m \cdot v_f}{\lambda} \cdot \frac{2e^2 E^2}{m^2 k^2} \cdot \left(\frac{df_0}{dv}\right)_{(v_f)}$$

$$\frac{dW}{dt} = \frac{2e^2 E^2}{\pi m} \cdot \frac{\omega}{k^2} \cdot \left(\frac{df_0}{dv}\right)_{(v_f)}$$

$$f_0(v) = \left(\frac{m}{2\pi\, k_b T}\right)^{\frac{1}{2}} \cdot \exp\left(\frac{-mv^2}{2\, k_b T}\right) \cdot n$$

$$\frac{m \cdot (v_a)^2}{2} = \frac{1}{2} k_b\, T$$

$$f_0(v) = \left(\frac{1}{2\pi}\right)^{\frac{1}{2}} \cdot \frac{1}{v_a} \cdot \exp\left[\frac{-v^2}{(v_a)^2}\right] \cdot n$$

$$\frac{df_0(v)}{dv} = -\left(\frac{2}{\pi}\right)^{\frac{1}{2}} \cdot \frac{v}{(v_a)^3} \cdot \exp\left[\frac{-v^2}{(v_a)^2}\right] \cdot n$$

$$\frac{dW}{dt} = -\left(\frac{2}{\pi}\right)^{\frac{3}{2}} \cdot \frac{e^2 E^2}{m} \cdot \frac{\omega}{k^2} \cdot \frac{v_f}{(v_a)^3} \cdot \exp\left[-\left(\frac{v_f}{v_a}\right)^2\right] \cdot n$$

$$\frac{dW}{dt} = -\left(\frac{2}{\pi}\right)^{\frac{3}{2}} \cdot \frac{e^2 E^2}{m} \cdot \frac{\omega^2}{k^3} \cdot \frac{1}{(v_a)^3} \cdot \exp\left[-\left(\frac{\omega}{k \cdot v_a}\right)^2\right] \cdot n$$

$$W = W_0 \cdot \exp(-2\gamma \cdot t)$$

$$\frac{dW}{dt} = -2\gamma \cdot W_0 \cdot \exp(-2\gamma \cdot t)$$

$$\gamma = -\left(\frac{1}{2}\right) \cdot \frac{1}{W} \cdot \frac{dW}{dt}$$

$$W = \frac{1}{2} \varepsilon_0 E^2$$

$$\gamma = \left(\frac{2}{\pi}\right)^{\frac{3}{2}} \cdot \frac{e^2 n}{\varepsilon_0 \cdot m} \cdot \frac{\omega^2}{k^3} \cdot \frac{1}{(v_a)^3} \cdot \exp\left[-\left(\frac{\omega}{k \cdot v_a}\right)^2\right]$$

$$\gamma = \left(\frac{2}{\pi}\right)^{\frac{3}{2}} \cdot \frac{(\omega_p)^2}{\varepsilon_0} \cdot \frac{\omega^2}{k^3} \cdot \frac{1}{(v_a)^3} \cdot \exp\left[-\left(\frac{\omega}{k \cdot v_a}\right)^2\right]$$