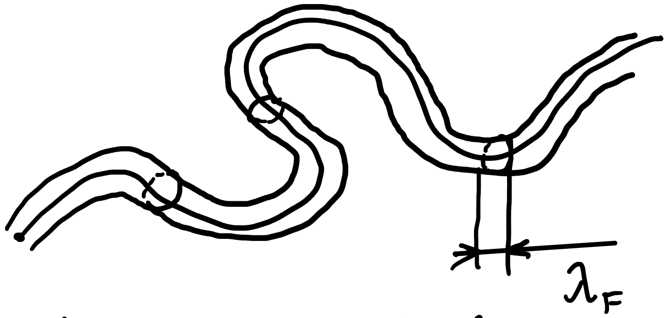
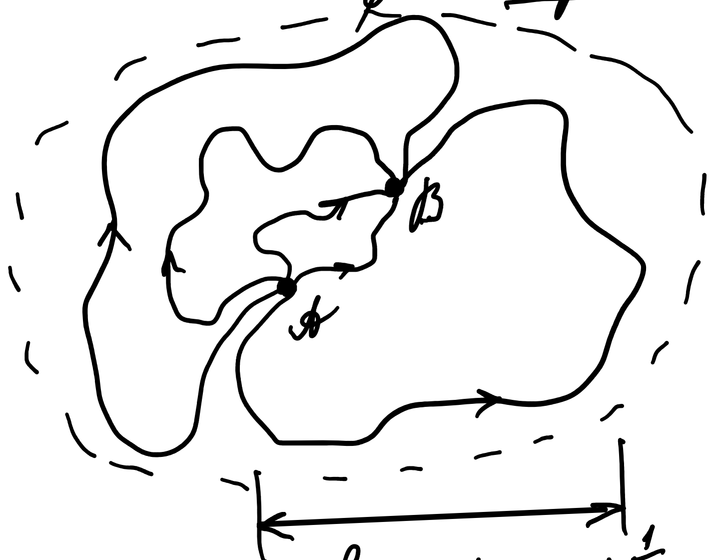
Weak-localisation corrections to conductivity

Trajectories have an effective width $\sim \lambda_F$



A tube of width $\sim \lambda_F$ around a trajectory

Introduce τ_φ – <u>dephasing time</u>



$$l_\varphi \sim (D\tau_\varphi)^{\frac{1}{2}}$$

The volume accessible to the quasiparticle after time t is $(Dt)^{\frac{d}{2}}$

(3D) On time dt the trajectory sweeps volume $\lambda_F^2 v_F\, dt$ (3D)

$$\frac{\lambda_F^2 v_F \, dt}{(Dt)^{\frac{3}{2}}}$$ – probability of return to the initial point and participate in interference

$$\int_{\tau}^{\tau_\varphi} \frac{v_F \lambda_F^2}{(Dt)^{\frac{3}{2}}} dt \sim \frac{v_F \lambda_F^2}{D^{\frac{3}{2}}} \left(\frac{1}{\tau^{\frac{1}{2}}} - \frac{1}{\tau_\varphi^{\frac{1}{2}}} \right) \sim \frac{v_F \lambda_F^2}{\tau^{\frac{1}{2}} D^{\frac{3}{2}}} \sim$$

$$D \sim v_F^2 \tau$$

$$\sim \frac{\lambda_F^2}{v_F^2 \tau^2} \sim (k_F l)^{-2}$$

Then $\frac{\delta \sigma}{\sigma} \sim -(k_F l)^{-2}$

Conductivity lowered by WL

(2D) $$-\frac{\delta\sigma}{\sigma} \sim \int_{\tau}^{\tau_\varphi} \frac{v_F \lambda_F \, dt}{Dt} \sim \frac{v_F \lambda_F}{\tau v_F^2} \ln\frac{\tau_\varphi}{\tau} \sim \frac{1}{k_F l} \ln\frac{\tau_\varphi}{\tau}$$

$$\delta\sigma \cong -\frac{e^2}{\hbar} \ln\frac{\tau_\varphi}{\tau} \cong -2\frac{e^2}{\hbar} \ln\frac{L_\varphi}{l}$$

// If there is a film of width b, there is an additional attenuation $\frac{\delta\sigma}{\sigma}$ of $\frac{\delta\sigma}{\sigma}$ by a factor of $\sim \frac{1}{k_F b}$ (because there are $\sim k_F b$ transverse channels, and quasiparticles have to hit the right channel to participate in interference

$$\delta\sigma_{2D} \sim -\frac{e^2}{\hbar} \frac{1}{k_F b} \ln\frac{L_\varphi}{l}$$

May be huge !!!

(1D) If there is only one 1D channel

$$\frac{\delta\sigma_1}{\sigma} \sim -\int_{\tau}^{\tau_\varphi} \frac{v_F\, dt}{(Dt)^{\frac{1}{2}}} \sim -\frac{v_F\ \tau_\varphi^{\frac{1}{2}}}{v_F\ \tau} = -\left(\frac{\tau_\varphi}{\tau}\right)^{\frac{1}{2}} = -\frac{L_\varphi}{\ell}$$

$$L_\varphi \sim \tau_\varphi^{\frac{1}{2}}$$

When there is a wire of diameter d,

$$\frac{\delta\sigma_1}{\sigma} \sim \frac{-1}{(k_F d)^2} \frac{L_\varphi}{\ell}$$

$$\delta\sigma_1 \sim -\frac{e^2}{\hbar} L_\varphi$$

Note: $\frac{\hbar}{e^2} = 4{,}110\ \Omega$

Reminder: $\sigma \sim \frac{e^2}{\hbar}(k_F \ell) \cdot k_F^{d-2}$