Single-particle interference effects

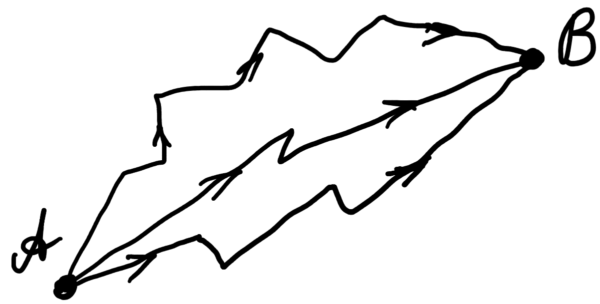
So far we considered essentially classical effects = there was no interference between quasiparticles.

Consider an electron, which is located at $\vec{r}=0$ at $t=0$. Then

$$P(\vec{r},t)=\frac{1}{(4\pi D t)^{\frac{d}{2}}}\, e^{-\frac{r^2}{4Dt}}$$

(in d dimensions), $D=\frac{l v_F}{d}=\frac{\tau v_F^2}{d}$; $\int P(\vec{r},t)\,d\vec{r}=1$

Consider quasiparticles propagation from A to B



$$P_{A\to B}=|A_1+A_2+\ldots+A_N|^2$$ - probability from the interference of N trajectories

when moving along a trajectory, the

$$A_i \sim e^{i(-k_F l_i + Et)}$$

quasiparticle arrival at the $-ik_F l_i$ factors

$A_i \sim e$

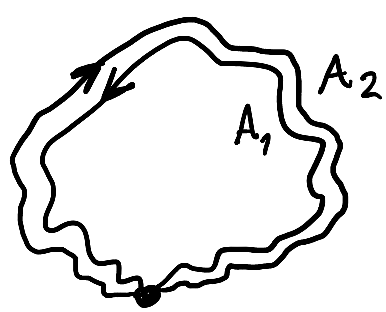
We consider quasiparticle arrival at the same time t, so compare only the $e^{-ik_F l_i}$ factors

They are very different

$$P_{A\to B} \approx |A_1|^2 + |A_2|^2 + \dots + |A_N|^2$$

– that implies no interference

Let us consider, however, the case when points A and B merge = the particle is coming back to where it started. But then all trajectories may be divided into 2 groups, going in opposite directions when compared to each other



$A_1 = A_2$

Constructive interference!

The probability density to return to the initial location is

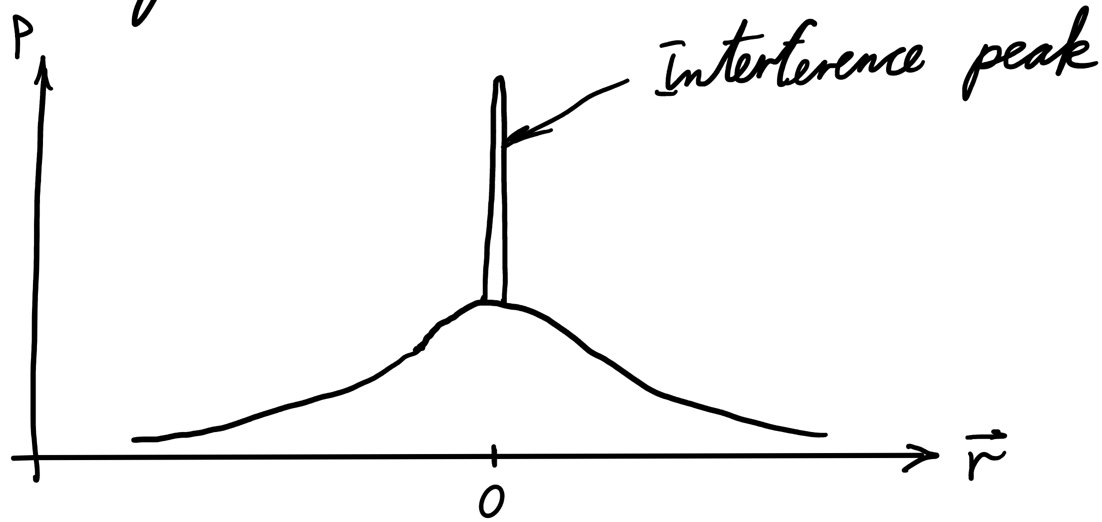
$$P_0 = |C_1 + C_2|^2 = \underbrace{|C_1|^2 + |C_2|^2}_{\text{Classical contribution}} + \underbrace{(C_1^* C_2 + C_1 C_2^*)}_{\text{Interference contribution}} \overset{C_1 = C_2 = C}{=} 4C^2$$

Classical contribution

interference contribution

Classically $P_0 = 2C^2$

So, due to interference the probability density of return to the same point doubles!!



So, interference <u>impedes</u> the propagation of quasiparticles