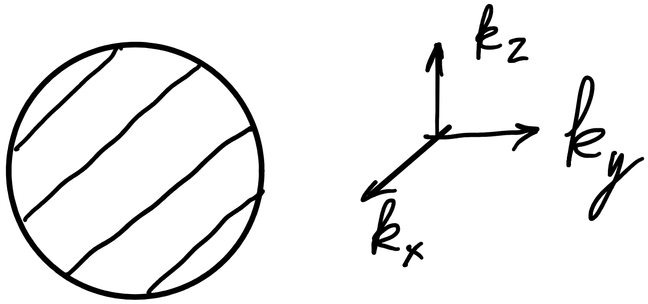
Elementary derivation of Drude formula

We've learnt that electrons in all solids are essentially strongly interacting systems. Landau Fermi-liquid theory states that they may be mapped onto a system of weakly interacting particles.

In equilibrium they fill the inside of a closed surface — the Fermi surface



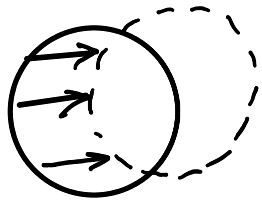
One may conveniently describe transport in such a system using the concept of quasiparticles — elementary excitations near the Fermi surface. These excitations weakly interact with each other.

They have an effective mass, an effective velocity near the FS, an effective DoS — all these parameters, however, have nothing to do with those of free electrons nothing [illegible]

Let's apply an external electric field

$\dot{\vec{k}} = e\vec{E}$ $\quad (e = -|e|)$

$\vec{k}(t) = \vec{k}(0) + e\vec{E}t$



Now, let's assume there is scattering by impurities

Let's assume electrons on average „forget" their momentum after time τ = momentum relaxation time

This maintains a steady distribution, a shifted Fermi sphere with

$\delta\vec{k} = e\vec{E}\tau$

That adds average velocity $\vec{v} = \frac{\delta\vec{k}}{m} = \frac{e\vec{E}\tau}{m}$ of each electron

$\vec{j} = ne\vec{v} = \frac{ne^2\tau}{m}\vec{E}$

$$\boxed{\sigma = \frac{ne^2\tau}{m}}$$

$$\sigma = \frac{ne^2 v_F \tau}{k_F}$$