1) a) Bragg diffraction at $\sin\theta = \frac{\lambda}{2d_{hkl}}$

h, k, l are Miller indices

for lattice constant a,

$$\sin\theta_{hkl} = \frac{\lambda}{2a}\sqrt{h^2+k^2+l^2}$$

b) to find $a = \sqrt[3]{\frac{4m_{Au}}{N_A \cdot \rho_{Au}}} \simeq 0.4nm$

c) fcc - lattice

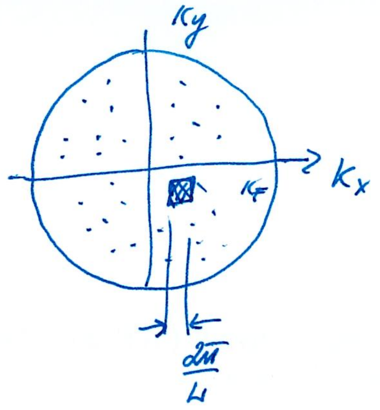
hkl	$\sin\theta_{hkl}$	θ_{hkl}
111	0.22	12.7°
200	0.25	14.5°
220	0.35	20.5°

d) bcc - lattice

hkl
110
200
222

some lines dissappear, i.e. 111, 220

(2)



Fermi circle

number of electronic states

$$N = 2\,\frac{\pi K_F^2}{\left(\frac{2\pi}{L}\right)^2} = \frac{1}{2\pi} K_F^2 \cdot L^2$$

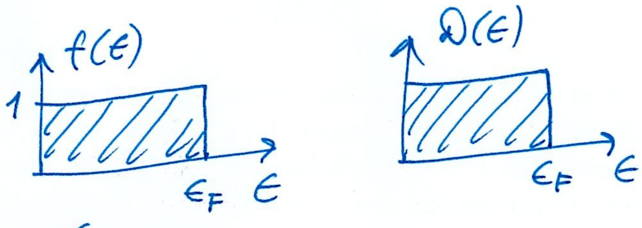
$$K_F = \sqrt{2\pi \cdot n}$$ concentration $= \frac{N}{S}$

$$\epsilon_F = \frac{\hbar^2 \cdot K_F^2}{2m} = \frac{\hbar^2 \cdot 2\pi \cdot n}{2m} = \frac{\pi \hbar^2}{m} \cdot n$$

$$\epsilon_F = \frac{\pi\hbar^2}{m}\,\frac{N}{S} \Rightarrow N = \frac{m \cdot S}{\pi \hbar^2} \cdot \epsilon_F$$

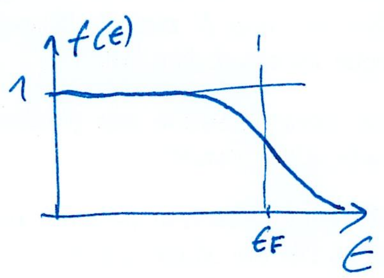
$$\mathcal{D}(\epsilon) = \frac{dN}{d\epsilon} = \frac{m \cdot S}{\pi \hbar^2}$$ (doesn't depend on ϵ)

@ $T = 0$



$$\langle \epsilon \rangle = \int_0^{\epsilon_F} d\epsilon \cdot \epsilon \cdot \mathcal{D}(\epsilon) \cdot f(\epsilon) = \underline{\epsilon_F / 2}$$

@ $T \neq 0$



$$\langle \epsilon \rangle = \int_0^{\infty} d\epsilon \cdot \epsilon \cdot \mathcal{D}(\epsilon) \cdot f(\epsilon) = \mathcal{D} \int_0^{\infty} d\epsilon \cdot \epsilon \cdot f(\epsilon)$$ complicated to analyze

at high temperature it behaves as ideal gas $\underline{\langle \epsilon \rangle \sim kT}$

<u>therefore it grows up!</u>

(3) Density of states

$$\mathcal{D}(\omega) = \frac{dN}{d\omega} = \frac{V \cdot K^2}{2\pi^2} \frac{dK}{d\omega}$$

Debye approximation $\omega = c \cdot K$

↳ speed of sound

$$\mathcal{D}(\omega) = V \cdot \omega^2 / 2\pi^2 \cdot c^3$$

@ 0K there is no phonons $\Rightarrow N = 0$

@ 300K $\quad N \sim \dfrac{V \cdot \omega^2 \Delta\omega}{2\pi^2 \cdot c^3} \sim \underline{1.5 \times 10^6}$

(5) $$\left(\Delta \frac{1}{B}\right) = \frac{2\pi e}{\hbar \cdot c \cdot S} \quad ; \quad S = \pi K_F^2$$

$$\Delta \frac{1}{B} \simeq \frac{2}{137 \cdot K_F^2 \cdot e} \sim 0.6 \times 10^{-8} \frac{1}{G}$$

extreme orbit $\quad R = \dfrac{v_F}{\omega_c} \quad ; \quad \omega_c = \dfrac{eB}{mc}$

$$R = \frac{\hbar K_F \cdot c}{e \cdot B} \sim 5 \times 10^{-4}\ \text{cm}$$

$$\pi R^2 \sim 0.7 \cdot 10^{-6}\ \text{cm}^2$$

4) a)

$$n = \frac{1}{R_H \cdot e} = \frac{j \cdot B_z}{E_H \cdot e} = \frac{40\,\mathrm{A\,cm^{-2}} \cdot 1\,\mathrm{Vs\,m^{-2}}}{8\,\mathrm{V\,cm^{-1}} \cdot 1{,}6 \cdot 10^{-19}\,\mathrm{As}}$$

$$R_H = \frac{E_H}{j B_z}$$

$$n = 3{,}12 \cdot 10^{15}\ \mathrm{cm^{-3}}$$

$$\tau = \frac{m\,\sigma}{n\,e^2} = \frac{7 \cdot 10^{-31}\,\mathrm{kg} \cdot 2\ \mathrm{A/Vcm}}{3{,}12 \cdot 10^{15}\,\mathrm{cm^{-3}}\,(1{,}6 \cdot 10^{-19}\,\mathrm{As})^2}$$

$$\tau = 1{,}75 \cdot 10^{-12}\ \mathrm{s}$$

b) Bedingung zur Messung der Zyklotronresonanz:

$$\omega_c \tau \gg 1$$

$$\omega_c = \frac{e B_z}{m} \rightsquigarrow B_z \geq \frac{m}{\tau e} = \frac{7 \cdot 10^{-31}\,\mathrm{kg}}{1{,}75 \cdot 10^{-12}\,\mathrm{s} \cdot 1{,}6 \cdot 10^{-19}\,\mathrm{As}}$$

$$B_z \geq 2{,}5\,\mathrm{T}$$

$$\left(\frac{\mathrm{kg}}{\mathrm{As^2}} = \frac{\mathrm{N}}{\mathrm{Am}} = \frac{\mathrm{Vs}}{\mathrm{m^2}} = \mathrm{T} \right)$$