Solid State Simulations

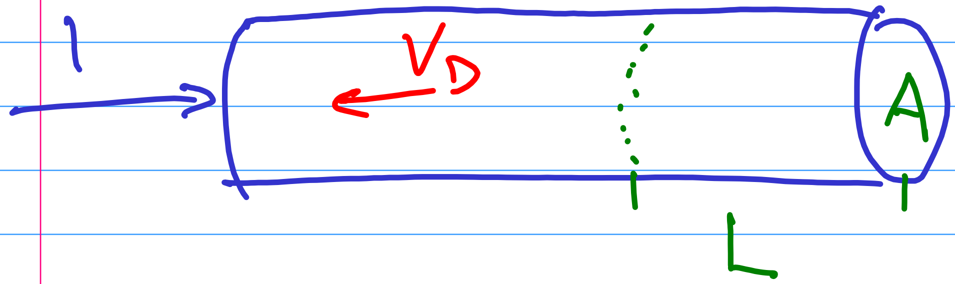
Strom mikroskopisch: Driftbewegung

$\vec{E} \rightarrow \vec{F} \rightarrow \vec{a} \rightarrow v \nearrow$?

Reibung erforderlich! (Ф1: fallende Kugel)

$\rightarrow$ stationäre Geschwindigkeit v_{DRIFT}

Strom mikroskopisch: Driftbewegung



während $t = L/v_D$ bewegt sich $q = \overbrace{ne}^{\text{Lad.-dichte}}\overbrace{AL}^{\text{Volum.}}$

durch A

$$\Rightarrow I = \frac{q}{t} = \frac{neAL}{L/v_D} \Rightarrow \boxed{j = \frac{I}{A} = n e v_D}$$

Cu: $1000 \frac{A}{cm^2}$ (viel!) $\quad n = 8{,}4 \cdot 10^{22}\,cm^{-3}$

$$\Rightarrow v_D \approx 1\,mm/s$$

Beschleunigung $a = \frac{e}{m} E$

Zeit zw. Stößen τ

eff. Geschw.? $s = \frac{1}{2} \frac{e}{m} E t^2$

$\Rightarrow v_D = \frac{s}{\tau} = \frac{1}{2} \frac{e}{m} E \tau$

$\Rightarrow j = n e v_D = n \frac{e^2}{2m} \tau E$

$\Rightarrow \rho = \frac{E}{j} = \frac{2m}{e^2 n \tau} \Longrightarrow \tau \approx 10\,\mathrm{fs}$ (@ 300K)

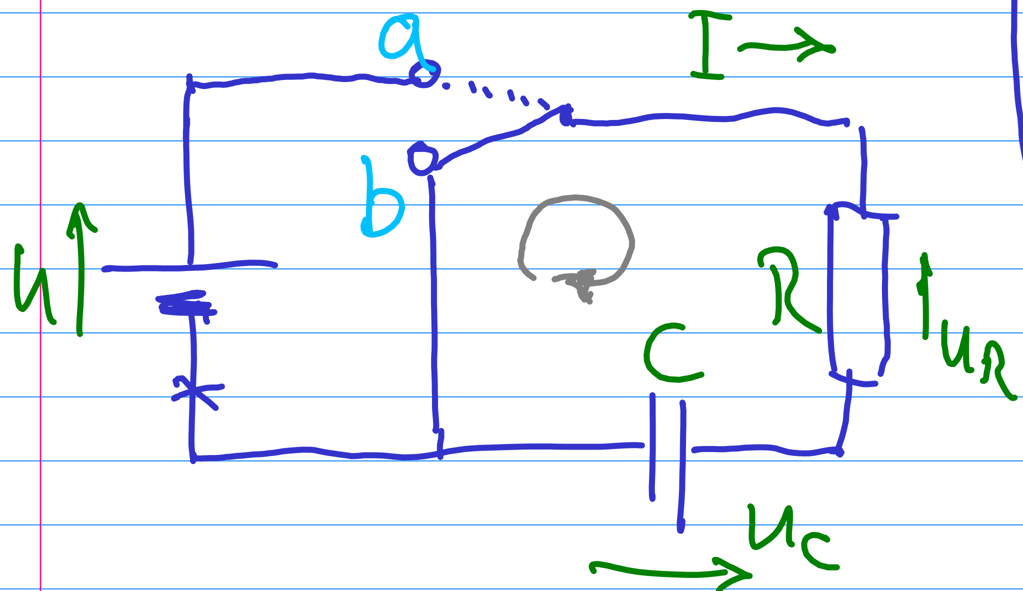
$\rho \downarrow$ bei $n \nearrow, \tau \nearrow$ ✓

zur num. Simulation:

Stoß löscht "Erinnerung"
neues v zufällig nach Boltzmann
τ : mittlere Zeit zwischen Stößen
eines Elektrons

RC-Kreise

Laden: Schalter in (a)



Maschenregel:

$$U - IR - \frac{Q}{C} = 0$$

$$I = \frac{dQ}{dt} \Rightarrow R\dot{Q} + \frac{Q}{C} = U$$

$$(*) \quad \dot{Q} + \frac{1}{RC} Q = \frac{U}{R}$$

Lsg. homogene Gl.:

$$Q_H = k e^{-t/RC}$$

$$Q = Q_H + Q_{sp}$$

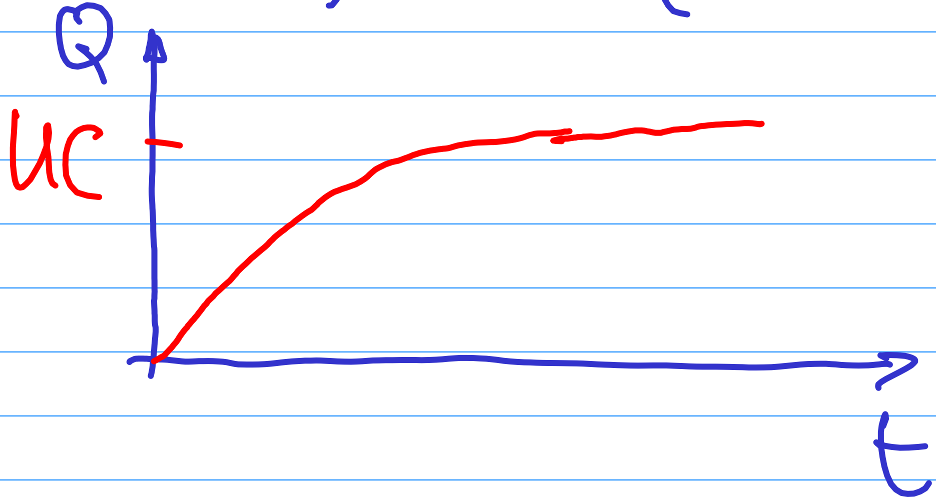
voll geladen: $\dot{Q} = 0 \Rightarrow Q_{sp} = UC$

$$Q(t) = UC + k\, e^{-t/RC}$$

Anfangsbed. $Q(t=0) = 0$

$$0 = UC + k \Rightarrow k = -UC$$

$$\Rightarrow Q(t) = UC\left(1 - e^{-t/RC}\right)$$



$RC = \tau$ Zeitkonstante

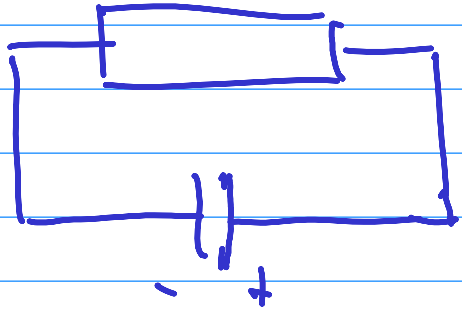
$t = 0 \ldots \tau$

$Q = UC \cdot 0{,}63$

$$I(t) = \dot{Q}(t) = \frac{U}{R} e^{-t/\tau}$$

$$V_C(t) = \frac{Q(t)}{C} = U\left(1 - e^{-t/\tau}\right)$$

(b) Entladen

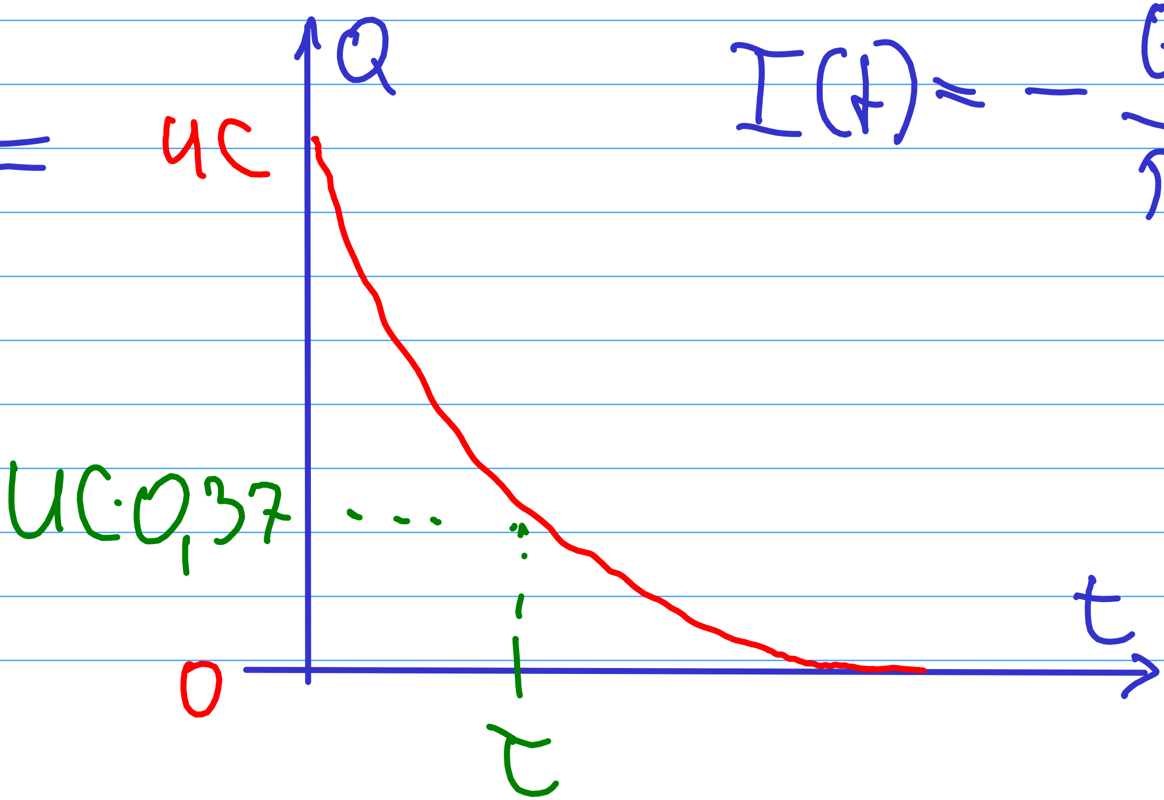


$$RI + \frac{Q}{C} = 0 = R\dot{Q} + \frac{Q}{C}$$

$$\Rightarrow Q(t) = Q_0 \, e^{-t/\tau}$$

$$I(t) = -\frac{Q_0}{RC} \, e^{-t/RC}$$

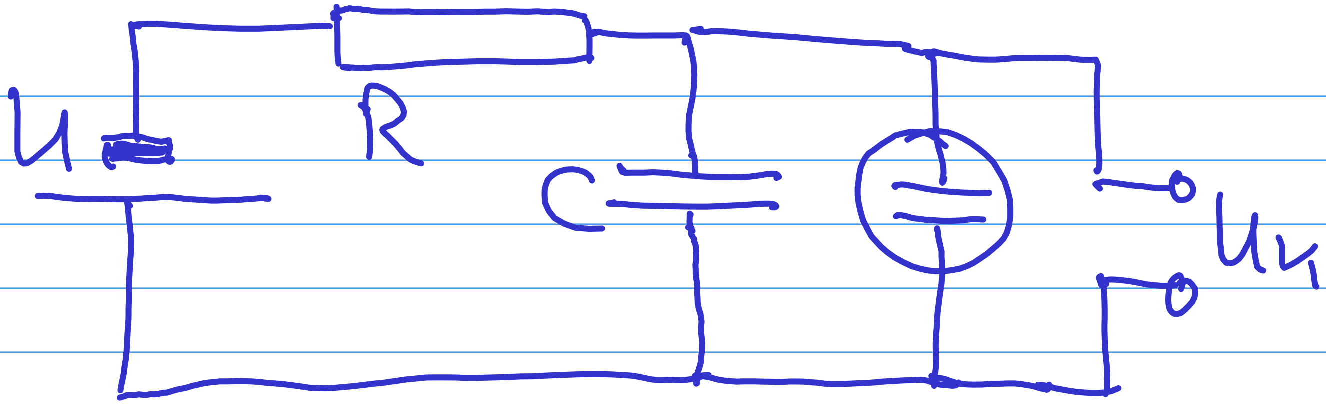
$Q_0 =$

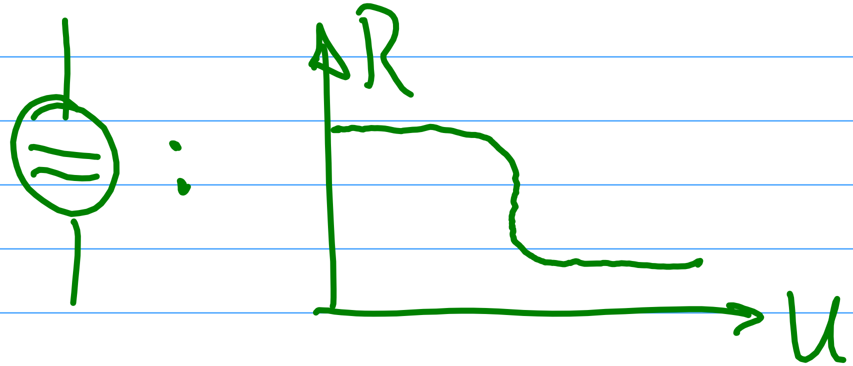


$$0 = R\dot{Q} + \frac{Q}{C}$$

$$0 = \dot{Q} + \frac{1}{RC}Q$$

$$e^{\alpha x} \longrightarrow \alpha e^{\alpha x}$$





Glimmlampe