Experimentalphysik III - Formelzettel

1 Konstanten

$c_0 = 299\ 792\ 458$ m/s	$g = 9.806\ 65$ m/s^2	$\varepsilon_0 = 8.854\ 187\ 817\ 10^{-12}$As/(Vm)
$e = 1.602\ 176\ 487\ \times 10^{-19}$C	$\mu_0 = 4 \cdot \pi\ \times 10^{-7}$Vs/(Am)	$m_e = 9.109\ 382\ 15\ \times 10^{-31}$kg
$m_p = 1.672\ 621\ 637\ \times 10^{-27}$kg	$h = 6.626\ 068\ 96\ \times 10^{-34}$Js	$\sigma = 5.670\ 400\ \times 10^{-8}$Wm^{-2}K^{-4}

2 Elektrodynamik

$$\oint_S \mathbf{B} \cdot \mathrm{d}\mathbf{A} = 0 \quad \Leftrightarrow \quad \nabla \cdot \mathbf{B} = 0$$

$$\oint_S \mathbf{E} \cdot \mathrm{d}\mathbf{A} = \frac{Q}{\varepsilon_0} \quad \Leftrightarrow \quad \nabla \cdot \mathbf{E} = \frac{\rho}{\varepsilon_0}$$

$$\oint_{\partial S} \mathbf{E} \cdot \mathrm{d}\mathbf{l} = -\frac{\partial \Phi_{B,S}}{\partial t} \quad \Leftrightarrow \quad \nabla \times \mathbf{E} = -\frac{\partial \mathbf{B}}{\partial t}$$

$$\oint_{\partial S} \mathbf{B} \cdot \mathrm{d}\mathbf{l} = \mu_0 I_{f,S} + \mu_0 \varepsilon_0 \frac{\partial \Phi_{E,S}}{\partial t} \quad \Leftrightarrow \quad \nabla \times \mathbf{B} = \mu_0 \mathbf{J}_f + \mu_0 \varepsilon_0 \frac{\partial \mathbf{E}}{\partial t}$$

Kraft auf Leiterelement: $d\mathbf{F} = I \cdot d\ell \times \mathbf{B}$

Kraftgesetz: $\mathbf{F} = q\left(\mathbf{E} + \mathbf{v} \times \mathbf{B}\right)$

magnetisches Dipolmoment: $\mathbf{m} = N \cdot I \cdot \mathbf{A}$

Drehmoment: $\mathbf{M} = \mathbf{m} \times \mathbf{B}$

$$\mathrm{d}\mathbf{B} = \frac{\mu_0 I}{4\pi} \cdot \frac{\mathrm{d}\mathbf{s} \times \hat{\mathbf{r}}}{r^2}$$

$$\mu_r = \frac{\mu}{\mu_0}$$

magnetischer Fluss: $\Phi = \int \mathbf{B} \cdot \mathrm{d}\mathbf{A}$

Induktionsgesetz:
$$U_{ind} = -N \frac{\mathrm{d}\boldsymbol{\Phi}}{\mathrm{d}t} = \oint \mathbf{E} \cdot \mathrm{d}\mathbf{s}$$

$$\frac{U_1}{U_2} = \frac{n_1}{n_2} = \frac{I_2}{I_1}$$

2.1 Wechselstrom

$$L_{\text{Reihe}} = \sum_i L_i$$

$$L_{\text{Parallel}} = \left(\sum_i \frac{1}{L_i}\right)^{-1}$$

$$L_{\text{Spule}} = \frac{\mu_0 A N^2}{l}$$

$$\mathbf{U} = -L\dot{\mathbf{I}}$$

$$W_{\text{Spule}} = \frac{1}{2}LI^2$$

$$W_{\text{Kondensator}} = \frac{1}{2}CU^2 = \frac{1}{2}\frac{Q^2}{C} = \frac{1}{2}QU$$

$$\text{Energiedichte: } w_m = \frac{1}{2}\left(\varepsilon_0 E^2 + \frac{B^2}{\mu_0}\right)$$

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

$$U_{\text{eff}} = \frac{U_0}{\sqrt{2}}$$

2.1.1 Spule

$$\begin{aligned} I &= I_0 \sin \omega t \\ U &= U_o \sin\left(\omega t + \frac{\pi}{2}\right) \\ X_L &= |Z_L| = \omega L \\ Z_L &= iX_L \end{aligned}$$

2.1.2 Kondensator

$$\begin{aligned} U &= \frac{Q}{C} \\ I &= I_0 \sin \omega t \\ U &= U_0 \sin\left(\omega t - \frac{\pi}{2}\right) \\ X_C &= |Z_C| = \frac{1}{\omega C} \\ Z_C &= -iX_C \end{aligned}$$

$$\begin{aligned} U &= Z \cdot I \\ |Z|_{\text{Reihe}} &= \sqrt{R^2 + (X_L - X_C)^2} \\ |Z|_{\text{Parallel}} &= \left(\sqrt{\left(\frac{1}{R}\right)^2 + \left(\frac{1}{X_L} - \frac{1}{X_C}\right)^2}\right)^{-1} \end{aligned}$$

$$\begin{aligned} \tan\varphi &= \left(\frac{X_L - X_C}{R}\right)_{\text{ser.}} = \left(\frac{\frac{1}{X_C} - \frac{1}{X_L}}{\frac{1}{R}}\right)_{\text{par.}} \\ \cos\varphi &= \frac{R}{Z} \end{aligned}$$

2.2 Elektromagnetische Wellen

$$\begin{aligned} c &= \frac{1}{\sqrt{\varepsilon_0 \mu_0}} \\ c &= \lambda \cdot f \\ \mathbf{B} &= \frac{1}{c}\hat{k} \times \mathbf{E} \end{aligned}$$

$$\text{Intensität: } I = |\langle \mathbf{S} \rangle_t| = \left|\left\langle \frac{1}{\mu_0}(\mathbf{E} \times \mathbf{B}) \right\rangle_t\right| = \frac{1}{2}c\varepsilon_0 |\mathbf{E}_0|^2$$

$$p_{\text{absorbtion}} = \frac{I}{c}$$

3 Optik

3.1 Strahlenoptik

$$n = \frac{c_0}{c}$$

$$\frac{1}{f} = \frac{1}{g} + \frac{1}{b}$$

$$\frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2} - \frac{d}{f_1 f_2}$$

$$\text{Vergrößerung: } m = \frac{B}{G} = -\frac{b}{g}$$

$$n_1 \sin\theta_1 = n_2 \sin\theta_2$$

$$\frac{1}{f} = (n-1)\left(\frac{1}{r_1} - \frac{1}{r_2}\right)$$

$$\frac{1}{f} = (n-1)\left[\frac{1}{r_1} - \frac{1}{r_2} + \frac{(n-1)\,d}{n r_1 r_2}\right]$$

$$\begin{aligned}
r_\parallel &= \frac{n_2\cos\theta_1 - n_1\cos\theta_2}{n_1\cos\theta_2 + n_2\cos\theta_1} \\
&= \frac{\tan(\theta_1-\theta_2)}{\tan(\theta_1+\theta_2)} \\
r_\perp &= \frac{n_1\cos\theta_1 - n_2\cos\theta_2}{n_1\cos\theta_1 + n_2\cos\theta_2} \\
&= -\frac{\sin(\theta_1-\theta_2)}{\sin(\theta_1+\theta_2)} \\
t_\parallel &= \frac{2n_1\cos\theta_1}{n_1\cos\theta_2 + n_2\cos\theta_1} \\
&= \frac{2\sin\theta_2\cos\theta_1}{\sin(\theta_1+\theta_2)\cos(\theta_1-\theta_2)} \\
t_\perp &= \frac{2n_1\cos\theta_1}{n_1\cos\theta_1 + n_2\cos\theta_2} \\
&= \frac{2\sin\theta_2\cos\theta_1}{\sin(\theta_1+\theta_2)}
\end{aligned}$$

$$\begin{aligned}
\left|\frac{E_r}{E_0}\right|^2 &= r_i^2 = R \\
\left|\frac{E_t}{E_0}\right|^2 &= t_i^2 = T \cdot \left(\frac{n_2\cos\theta_2}{n_1\cos\theta_1}\right)^{(-1)} \\
R + T &= 1 \\
I_t &= \frac{n_2\cos\theta_2}{n_1\cos\theta_1} t^2 \cdot I_0 = I_0 - I_r
\end{aligned}$$

$$\sin\theta_{\text{total}} = \frac{n_2}{n_1}$$

$$\tan\theta_{\text{Brewster}} = \frac{n_2}{n_1}$$

3.2 Interferenz

$$\lambda_n = \frac{\lambda}{n}$$

$$\text{Phasendifferenz: } \delta = \frac{2\pi}{\lambda_n}\Delta$$

3.2.1 Gitter

$$\sin\theta_{\text{min,B}} = k\frac{\lambda}{b}$$

$$\sin\theta_{\text{max,B}} = \left(k + \frac{1}{2}\right)\frac{\lambda}{b}$$

$$\sin\theta_{\text{max,I}} = k\frac{\lambda}{d}$$

$$\sin\theta_{\text{min,I}} = \left(k + \frac{1}{2}\right)\frac{\lambda}{d}$$

$$I(\theta) = I_0 \underbrace{\frac{\sin^2\left(\frac{\pi b}{\lambda}\sin\theta\right)}{\left(\frac{\pi b}{\lambda}\sin\theta\right)^2}}_{\text{Beugung}} \cdot \underbrace{\frac{\sin^2\left(N\frac{\pi d}{\lambda}\sin\theta\right)}{\sin^2\left(\frac{\pi d}{\lambda}\sin\theta\right)}}_{\text{Interferenz}}$$

$$\text{Auflösungsvermögen: } A = \frac{\lambda}{\Delta\lambda} = kN$$

$$\sin\theta_{\text{Rayleigh}} = 1.22\frac{\lambda}{d}$$

4 Quantenmechanik

$$p = \frac{h}{\lambda}$$

$$E_{kin} = Uq = h\nu - W_a$$

$$\Delta\lambda = \frac{h}{m_0 c}(1 - \cos\theta)$$

$$\lambda_{\max} = \frac{b}{T} \quad (b = 2.897\,7685\ 10^{-3}\text{mK})$$

$$P = \sigma\varepsilon A T^4$$

$$\Delta x \Delta p \geq h$$