# 1. Elektromagnetische Welle im Vakuum

$$E_x = 0; \quad E_y = 30\cos\left(2\pi * 10^8 t - \frac{2\pi}{3}x\right); \quad E_z = 0$$

(a) $\omega = 2\pi * 10^8 \text{ 1/s}$

$f = \frac{\omega}{2\pi} = \underline{\underline{10^8 \text{ 1/s}}}$

(b) $k = \frac{2\pi}{3}$

$\lambda = \frac{2\pi}{k} = \underline{\underline{3 \text{ m}}}$

(c)

Direction: $\underline{\underline{\hat{x}}}$

(d) $B_0 = \frac{E_0}{c}$

$\vec{B} = \underline{\underline{10^7 \cos\left(2\pi * 10^8 t - \frac{2\pi}{3}x\right)}}$

# 2. Photonen-Ping-Pong

(a)

| Linear Polarization | Circular Polarization | Elliptical Polarization |
|---|---|---|
| $\vec{E}_1(t) = E_0 \begin{pmatrix}\cos(\omega t)\\0\\0\end{pmatrix}$ | $\vec{E}_2(t) = E_0 \begin{pmatrix}\cos(\omega t)\\\sin(\omega t)\\0\end{pmatrix}$ | $\vec{E}_3(t) = E_0 \begin{pmatrix}a\cos(\omega t)\\b\sin(\omega t)\\0\end{pmatrix}$ |
| $w_{rms} = \frac{\epsilon_0 E_0^2}{2}$ | $w_{rms} = \epsilon_0 E_0^2$ | $w_{rms} = \frac{\epsilon_0 E_0^2(a^2+b^2)}{2}$ |
| $I_{rms} = \frac{c\epsilon_0 E_0^2}{2}$ | $I_{rms} = c\epsilon_0 E_0^2$ | $I_{rms} = \frac{c\epsilon_0 E_0^2(a^2+b^2)}{2}$ |

(b) $\vec{F} = \frac{\mathrm{d}\vec{p}}{\mathrm{d}t} = \frac{P}{c} = \epsilon_0 E_{\mathrm{rms}}^2 A$

$$F_1 = \epsilon_0 E_{\mathrm{rms}}^2 A$$
$$F_2 = 2\epsilon_0 E_{\mathrm{rms}}^2 A$$
$$F_3 =$$

(c)

## 3. Stehende Wellen

$$\vec{E}(\vec{r}, t) = \mathrm{Re}\left(\vec{E}_0\, \mathrm{e}^{i\vec{k}\vec{r} - i\omega t}\right)$$

(a)

$$\vec{E}_1(x\hat{x}, t) = \mathrm{Re}\left(\vec{E}_0\, \mathrm{e}^{ik_x x - i\omega t}\right)$$
$$\vec{E}_2(-x\hat{x}, t) = \mathrm{Re}\left(\vec{E}_0\, \mathrm{e}^{-ik_x x - i\omega t}\right)$$

$$\begin{aligned}\vec{E} &= \vec{E}_1 + \vec{E}_2 = \mathrm{Re}\left(\vec{E}_0\left[\mathrm{e}^{ik_x x - i\omega t} + \mathrm{e}^{-ik_x x - i\omega t}\right]\right) = \\ &= \mathrm{Re}\left(\vec{E}_0\, \mathrm{e}^{-i\omega t}\right) * 2\cos(k_x x)\end{aligned}$$

For $x = \frac{n\pi}{k_x}$, $n \in \mathbb{N}$: $\quad \cos(k_x x) = 0 \quad \Rightarrow \quad \vec{E} = 0$

$\Rightarrow$ $\vec{E}$ describes a standing Wave

(b)

$$\vec{E}_1(x\hat{x}, t) = \mathrm{Re}\left(\vec{E}_0\, \mathrm{e}^{ik_x x - i\omega t}\right)$$
$$\vec{E}_2(y\hat{y}, t) = \mathrm{Re}\left(\vec{E}_0\, \mathrm{e}^{ik_y y - i\omega t}\right)$$

$$\begin{aligned}\vec{E} &= \vec{E}_1 + \vec{E}_2 = \mathrm{Re}\left(\vec{E}_0\left[\mathrm{e}^{ik_x x - i\omega t} + \mathrm{e}^{ik_y y - i\omega t}\right]\right) = \\ &= \mathrm{Re}\left(\vec{E}_0\, \mathrm{e}^{-i\omega t}\right) * 2\cos(k_x x)\end{aligned}$$

For $x = \frac{n\pi}{k_x}$, $n \in \mathbb{N}$ : $\quad \cos(k_x x) = 0 \quad \Rightarrow \quad \vec{E} = 0$

$\Rightarrow$ $\vec{E}$ describes a standing Wave

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(c)

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(d) $\omega_1 = 2\omega_2$

$$\vec{E}_1(\hat{x}, t) = \mathrm{Re}\left(\vec{E}_0\, \mathrm{e}^{i\vec{k}\hat{x} - i\omega_1 t}\right)$$

$$\vec{E}_2(-\hat{x}, t) = \mathrm{Re}\left(\vec{E}_0\, \mathrm{e}^{-i\vec{k}\hat{x} - i\omega_2 t}\right)$$

$$\vec{E} = \vec{E}_1 + \vec{E}_2 = \mathrm{Re}\left(\vec{E}_0\, \mathrm{e}^{i\vec{k}\hat{x} - i2\omega_2 t} + \mathrm{e}^{-i\vec{k}\hat{x} - i\omega_2 t}\right)$$