$$
\begin{aligned}
\nabla \cdot \mathbf{E} &= \rho/\varepsilon_0 \qquad \text{(Gauß)} \\
\nabla \cdot \mathbf{B} &= 0 \qquad \text{(no magnetic monopoles)} \\
\nabla \times \mathbf{E} &= -\partial_t \mathbf{B} \qquad \text{(Faraday)} \\
\nabla \times \mathbf{B} &= \mu_0 \mathbf{J} \qquad \text{(Ampère)}
\end{aligned}
$$

$$\nabla \cdot (\nabla \times \mathbf{V}) \equiv 0$$

V

$$\nabla \cdot (\nabla \times \mathbf{E}) = -\partial_t (\nabla \cdot \mathbf{B}) = 0 \qquad \text{(all good)}$$

$$\nabla \cdot (\nabla \times \mathbf{B}) = \mu_0 \nabla \cdot \mathbf{J} \neq 0 \qquad \text{(problem!)}$$

$$\nabla \cdot \mathbf{J} = -\partial_t \rho$$

$$\nabla \cdot \mathbf{J} = 0$$

$$
\begin{aligned}
\nabla \cdot \mathbf{J} &= -\frac{\partial \rho}{\partial t} \\
&= -\frac{\partial}{\partial t}\left(\varepsilon_0 \nabla \cdot \mathbf{E}\right) = -\nabla \cdot \left(\varepsilon_0 \frac{\partial \mathbf{E}}{\partial t}\right)
\end{aligned}
$$

$$\mu_0 \varepsilon_0 \frac{\partial \mathbf{E}}{\partial t}$$

J

$$\nabla \times \mathbf{B} = \mu_0 \mathbf{J} + \mu_0 \varepsilon_0 \frac{\partial \mathbf{E}}{\partial t} \qquad \text{(Ampère's law with Maxwell's correction)}$$

$$\varepsilon_0 \frac{\partial \mathbf{E}}{\partial t}$$

$$
\begin{aligned}
\nabla \cdot \mathbf{D} &= \rho_f \\
\nabla \cdot \mathbf{B} &= 0 \\
\nabla \times \mathbf{E} &= -\frac{\partial \mathbf{B}}{\partial t} \\
\nabla \times \mathbf{H} &= \frac{\partial \mathbf{D}}{\partial t} + \mathbf{J}_f
\end{aligned}
$$

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

$\sigma, \varepsilon, \mu, \ldots$

$$\mathbf{P}(\mathbf{r},t) = \varepsilon_0 \left(\overline{\overline{\chi}}_e^{(1)} \mathbf{E}(\mathbf{r},t) + \overline{\overline{\chi}}_e^{(2)} \mathbf{E}^2(\mathbf{r},t) + \overline{\overline{\chi}}_e^{(3)} \mathbf{E}^3(\mathbf{r},t) + \ldots \right)$$
$$\mathbf{P}(\mathbf{r},t) = \varepsilon_0 \overline{\overline{\chi}}_e \mathbf{E}(\mathbf{r},t)$$

χ_e

P

E

P

$$\mathbf{P}(\mathbf{r},t)=\varepsilon_0\int d\mathbf{r}'\chi\left(\mathbf{r}'-\mathbf{r},t\right)\mathbf{E}\left(\mathbf{r}',t\right)$$

$$\underline{\mathbf{P}}(\mathbf{k},t) = \varepsilon_0 \underline{\chi_e}(\mathbf{k},t)\underline{\mathbf{E}}(\mathbf{k},t)$$

$$\to \varepsilon(\mathbf{k}, \omega)$$