Eletromagnetismo Avançado

14 de setembro
Ondas Eletromagnéticas

Equações de onda

$$\nabla^2 \vec{\mathbf{E}} = \frac{1}{c^2} \frac{\partial^2 \vec{\mathbf{E}}}{\partial t^2}$$

$$\nabla^2 \vec{\mathbf{B}} = \frac{1}{c^2} \frac{\partial^2 \vec{\mathbf{B}}}{\partial t^2}$$

Condições livres

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$$\vec{\mathbf{E}}(\vec{\mathbf{r}},t) = \vec{\mathbf{E}}_0 \exp\Big(i(\vec{\mathbf{k}}\cdot\vec{\mathbf{r}} - \omega t)\Big)$$

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$$\partial_t f \quad \Rightarrow \quad -i\omega f$$

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$$\omega = kc$$

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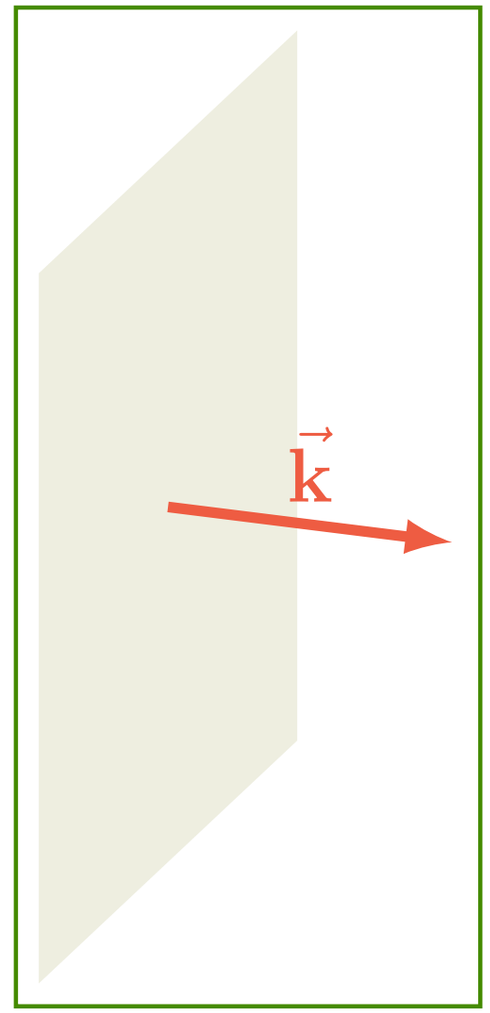

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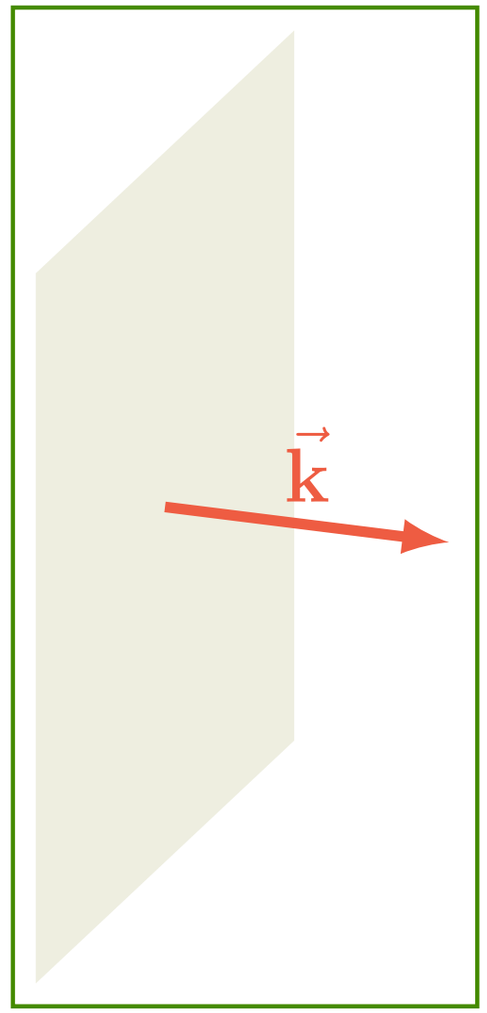

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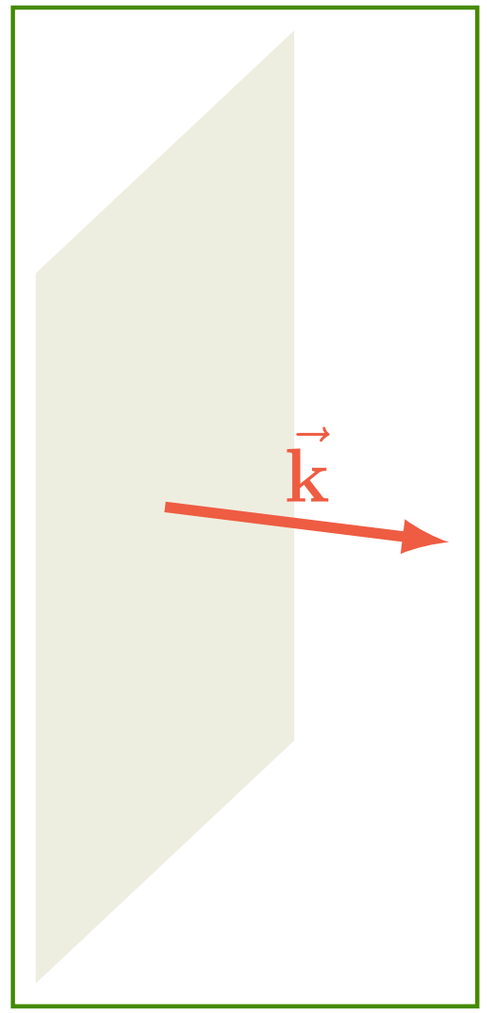

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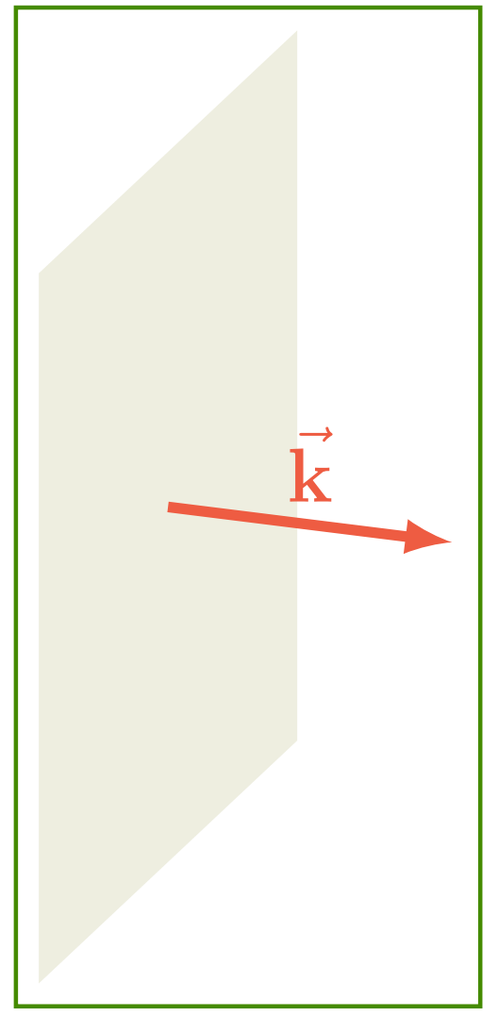

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$$\vec{\boldsymbol{\nabla}}\cdot\vec{\mathbf{B}} = 0 \quad \Rightarrow \quad \vec{\mathbf{k}}\cdot\vec{\mathbf{B}}_0 = 0$$

$$\vec{\boldsymbol{\nabla}}\times\vec{\mathbf{E}} = -\frac{\partial\vec{\mathbf{B}}}{\partial t} \quad \Rightarrow \quad \vec{\mathbf{k}}\times\vec{\mathbf{E}}_0 = \omega\vec{\mathbf{B}}_0$$

$$\frac{\vec{\mathbf{k}}\times\vec{\mathbf{E}}_0 = \omega\vec{\mathbf{B}}_0}{k} \quad \Rightarrow \quad \hat{\mathbf{k}}\times\vec{\mathbf{E}}_0 = c\vec{\mathbf{B}}_0$$

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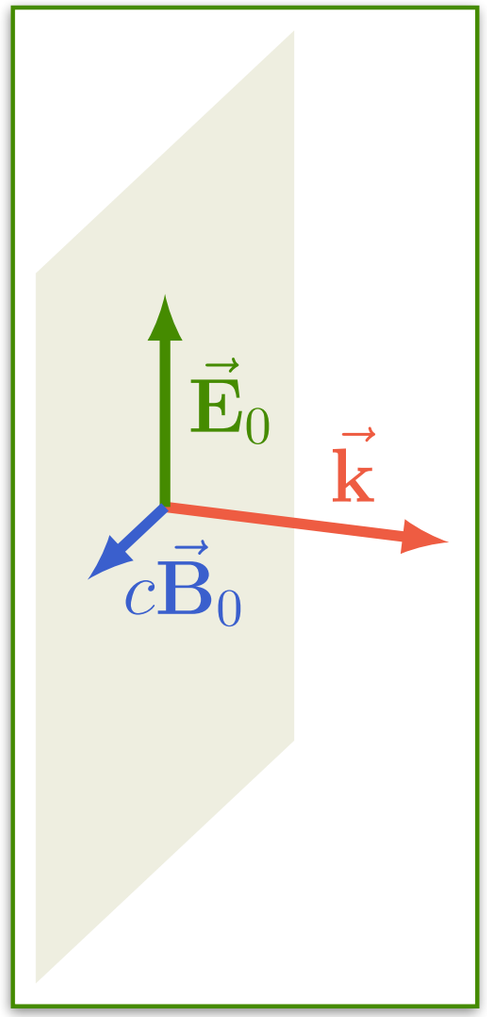

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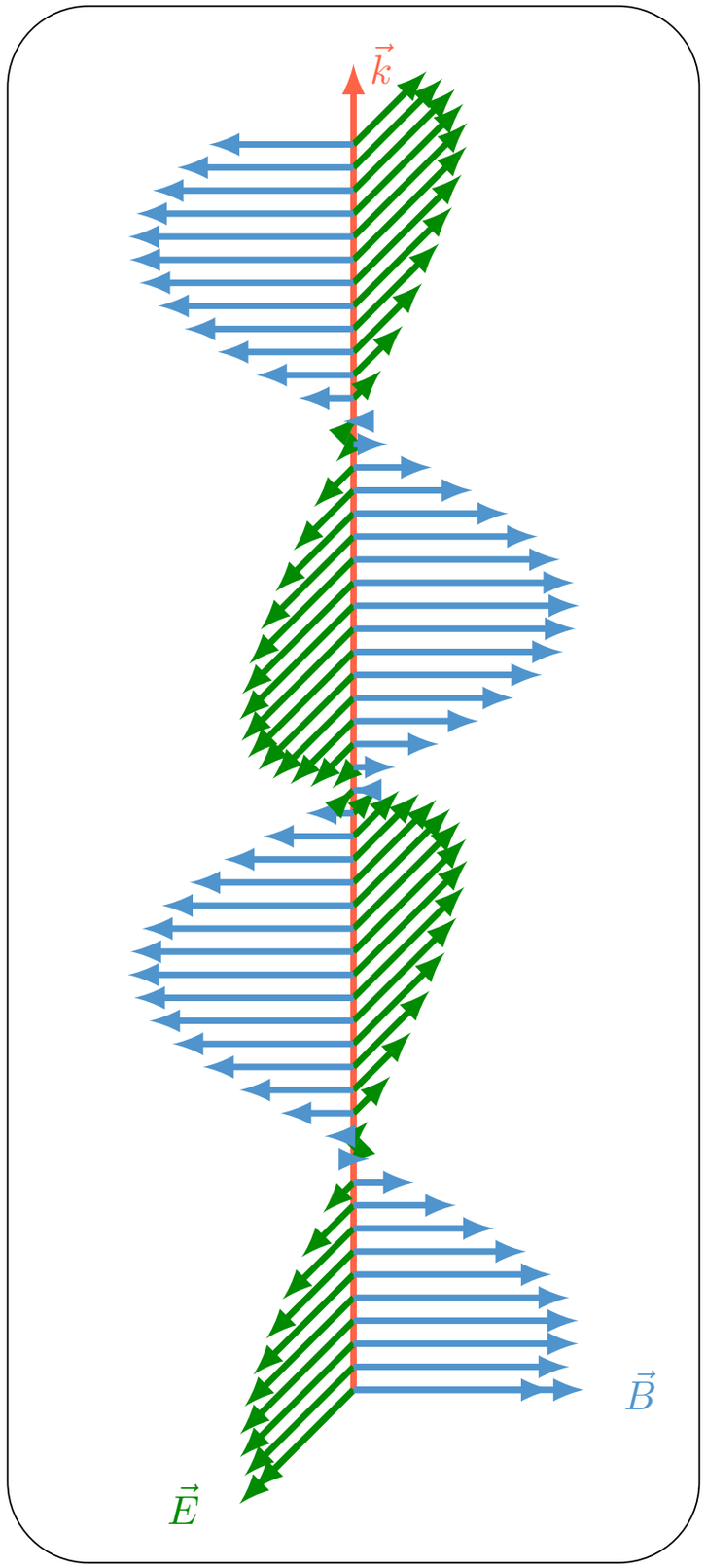
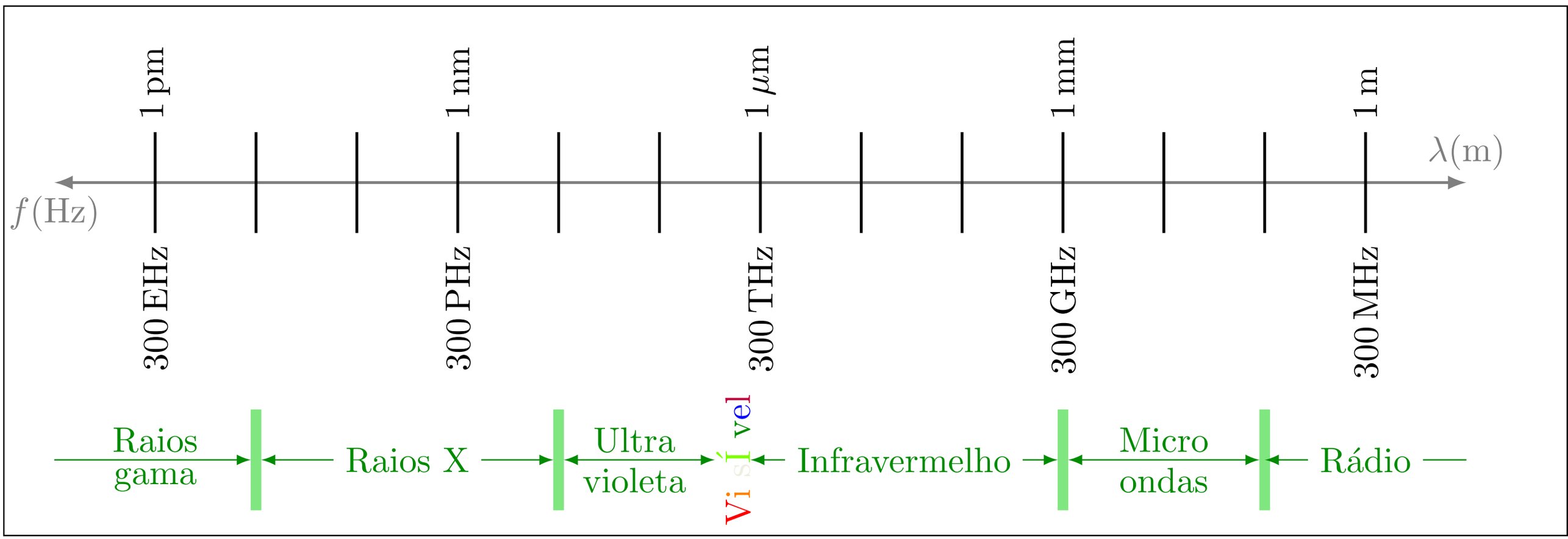


Espectro


1 pm
1 nm
1 μm
1 mm
1 m
λ(m)
f(Hz)
300 EHz
300 PHz
300 THz
300 GHz
300 MHz
Raios gama
Raios X
Ultra violeta
Visível
Infravermelho
Micro ondas
Rádio

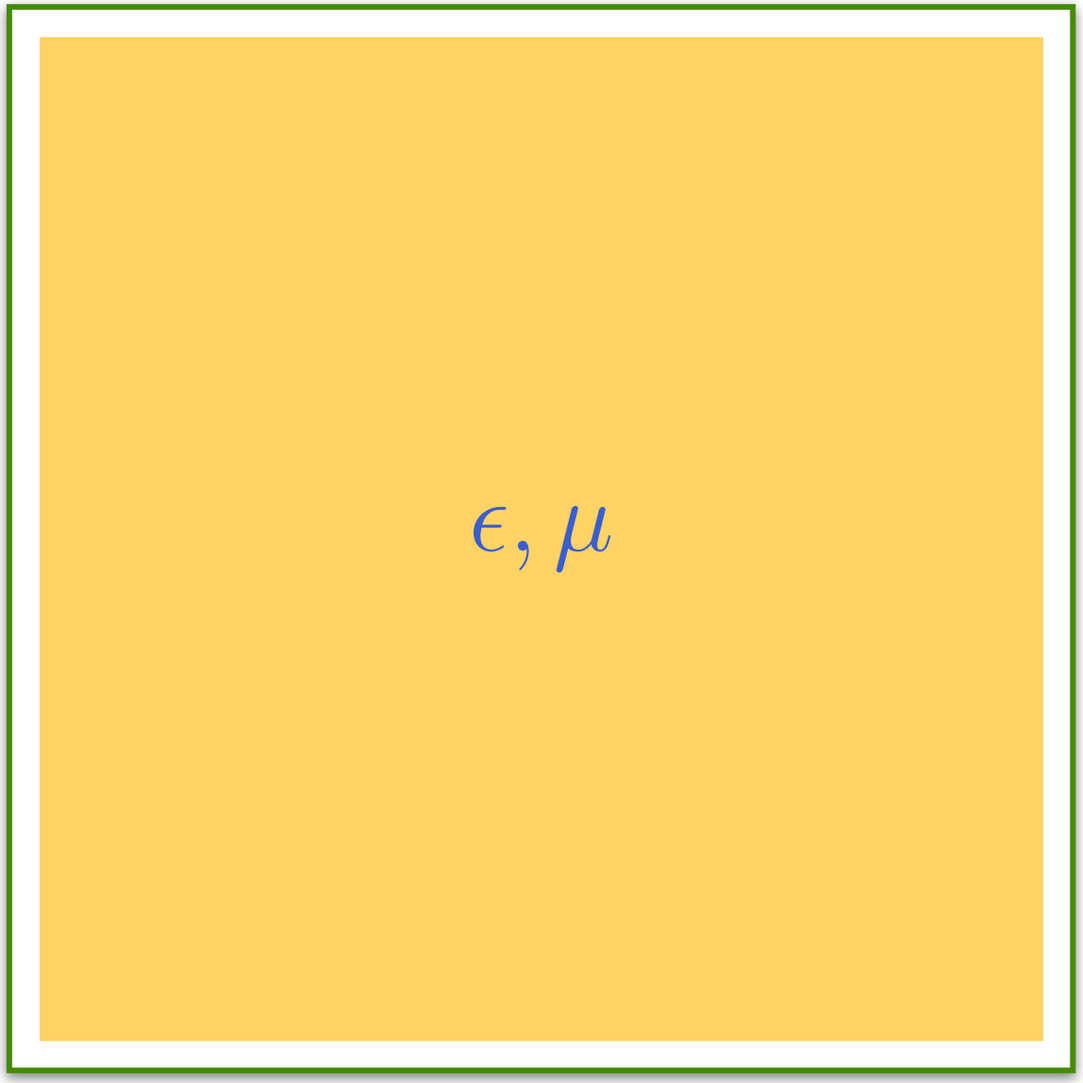
Meios lineares

$$\vec{\nabla} \cdot \vec{\mathbf{E}} = \frac{\rho}{\epsilon}$$

$$\vec{\nabla} \times \vec{\mathbf{E}} = -\partial_t \vec{\mathbf{B}}$$

$$\vec{\nabla} \cdot \vec{\mathbf{B}} = 0$$

$$\vec{\nabla} \times \vec{\mathbf{B}} = \mu(\vec{\mathbf{J}} + \epsilon \partial_t \vec{\mathbf{E}})$$



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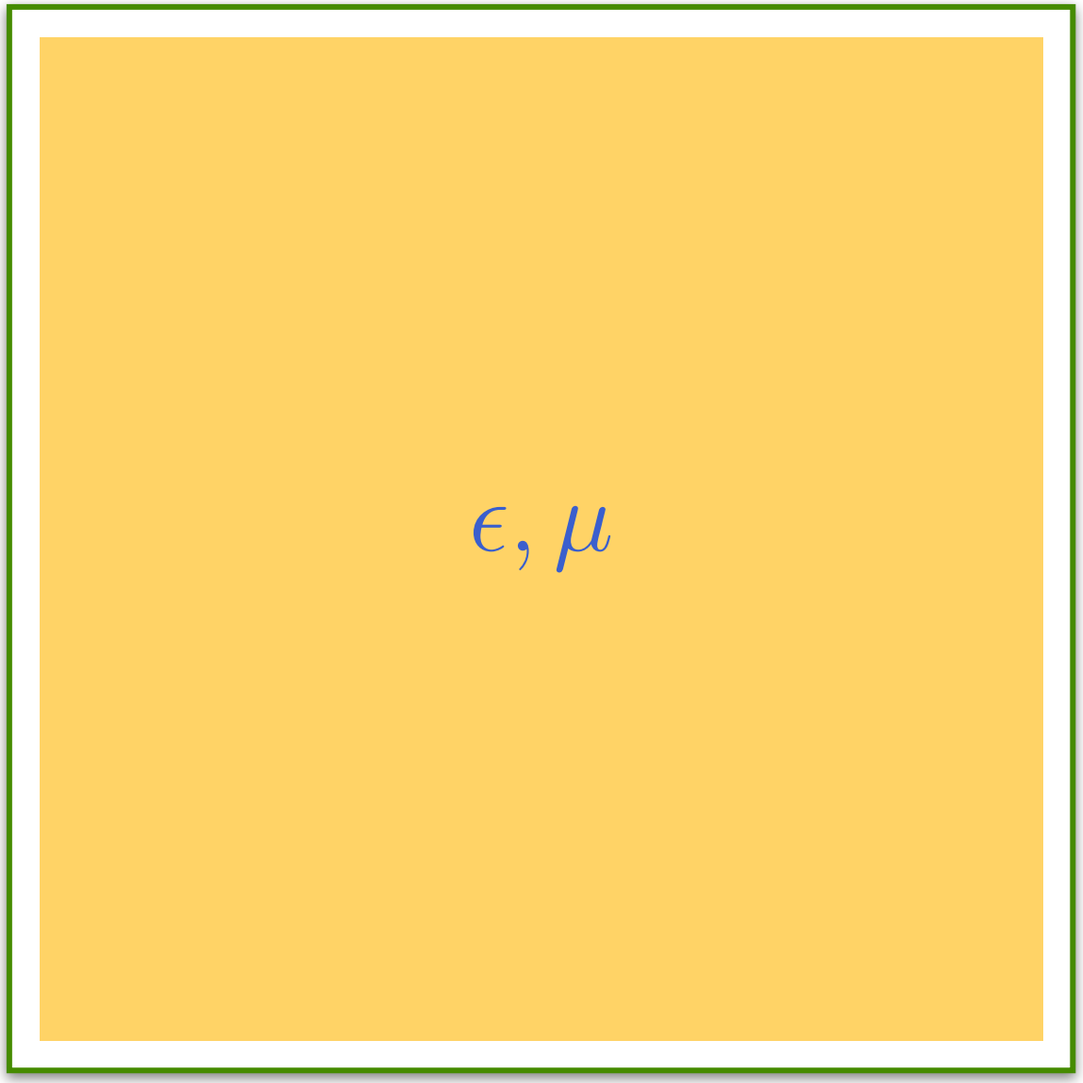

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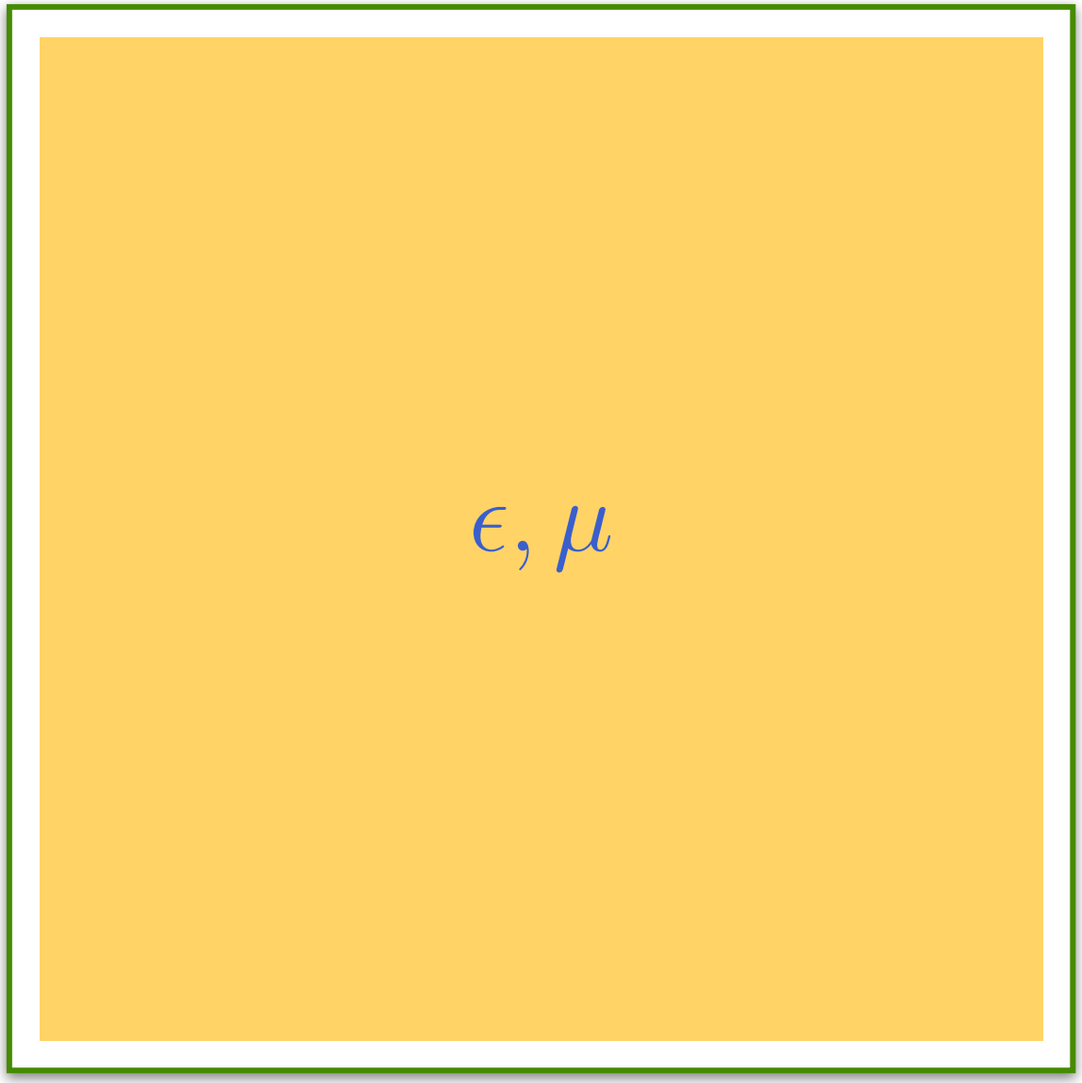

$$\nabla^2 \vec{\mathbf{E}} = \mu\epsilon \partial_t^2 \vec{\mathbf{E}}$$

$$\nabla^2 \vec{\mathbf{E}} = \frac{1}{v^2} \partial_t^2 \vec{\mathbf{E}} \quad (v \equiv \frac{c}{n})$$

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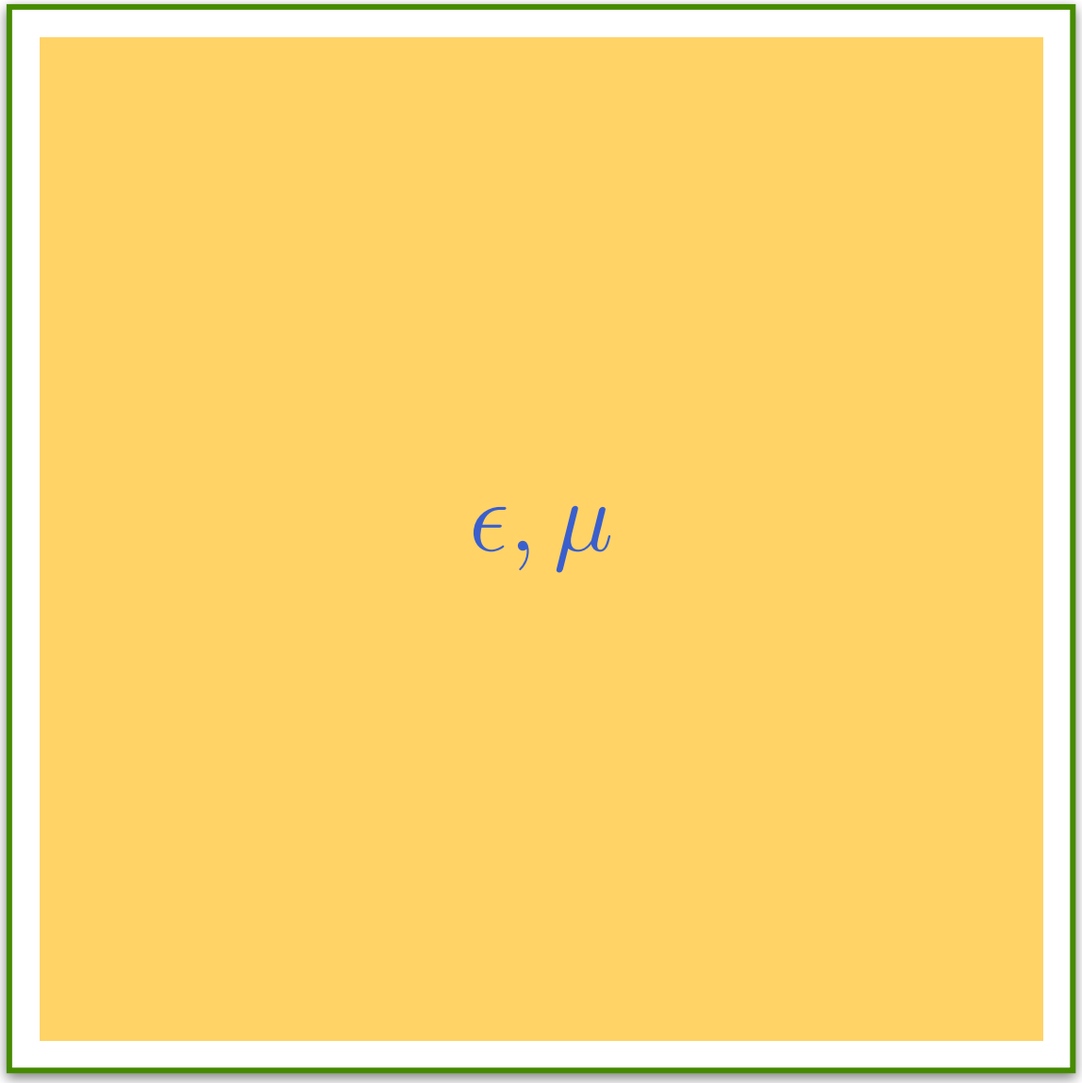

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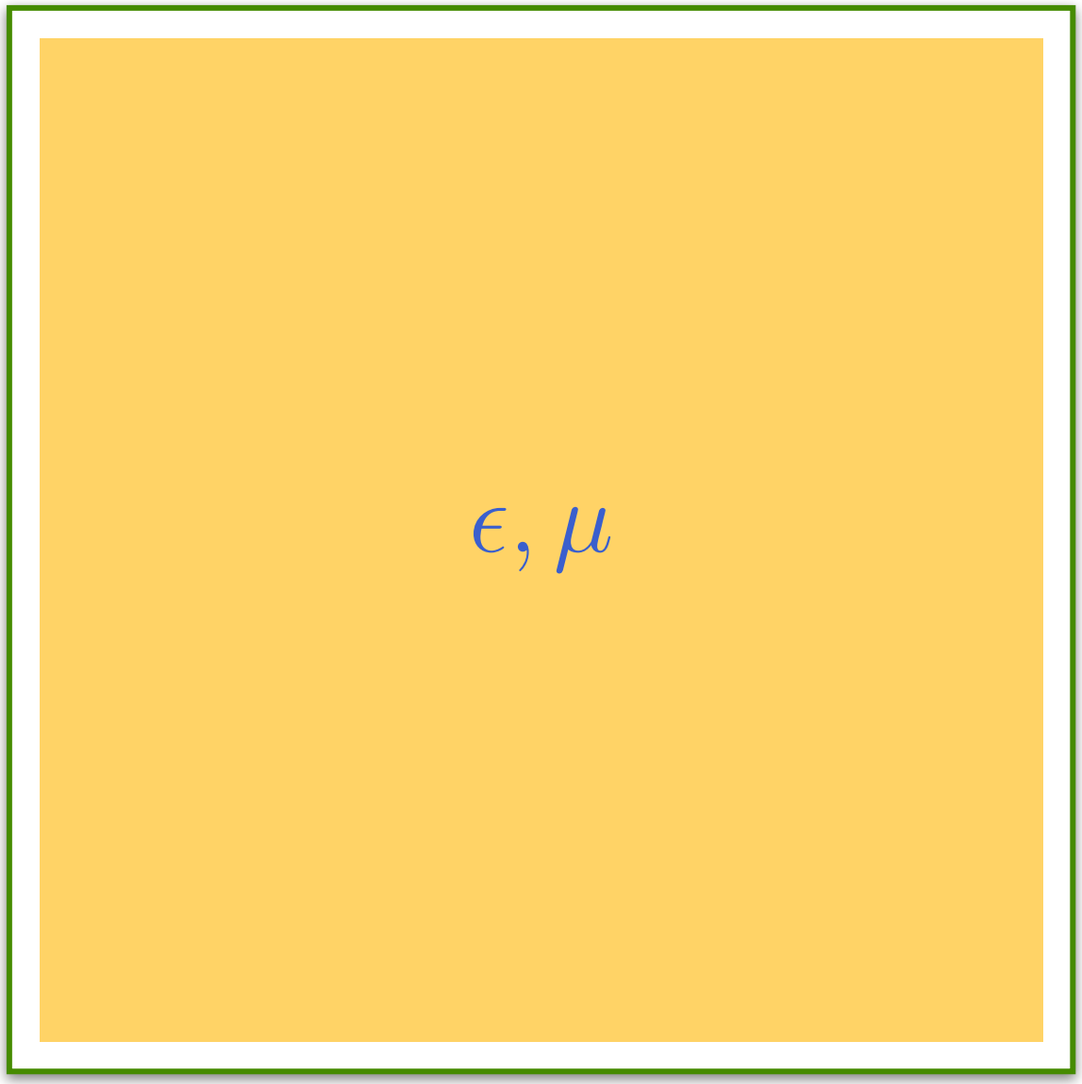

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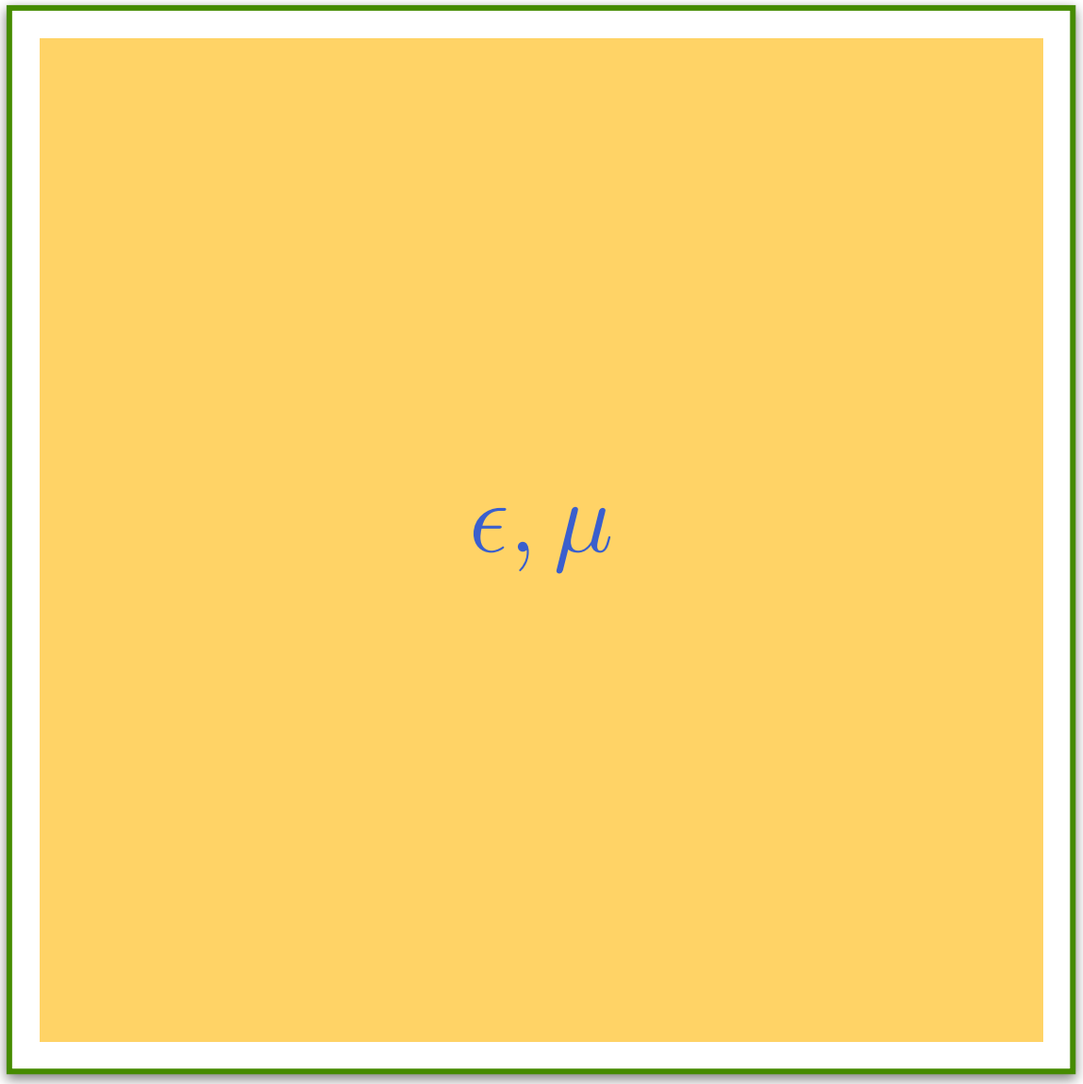

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$$\omega = \frac{kc}{n}$$

$$\hat{\mathbf{k}}\times\vec{\mathbf{E}}_0 = \frac{c}{n}\vec{\mathbf{B}}_0$$

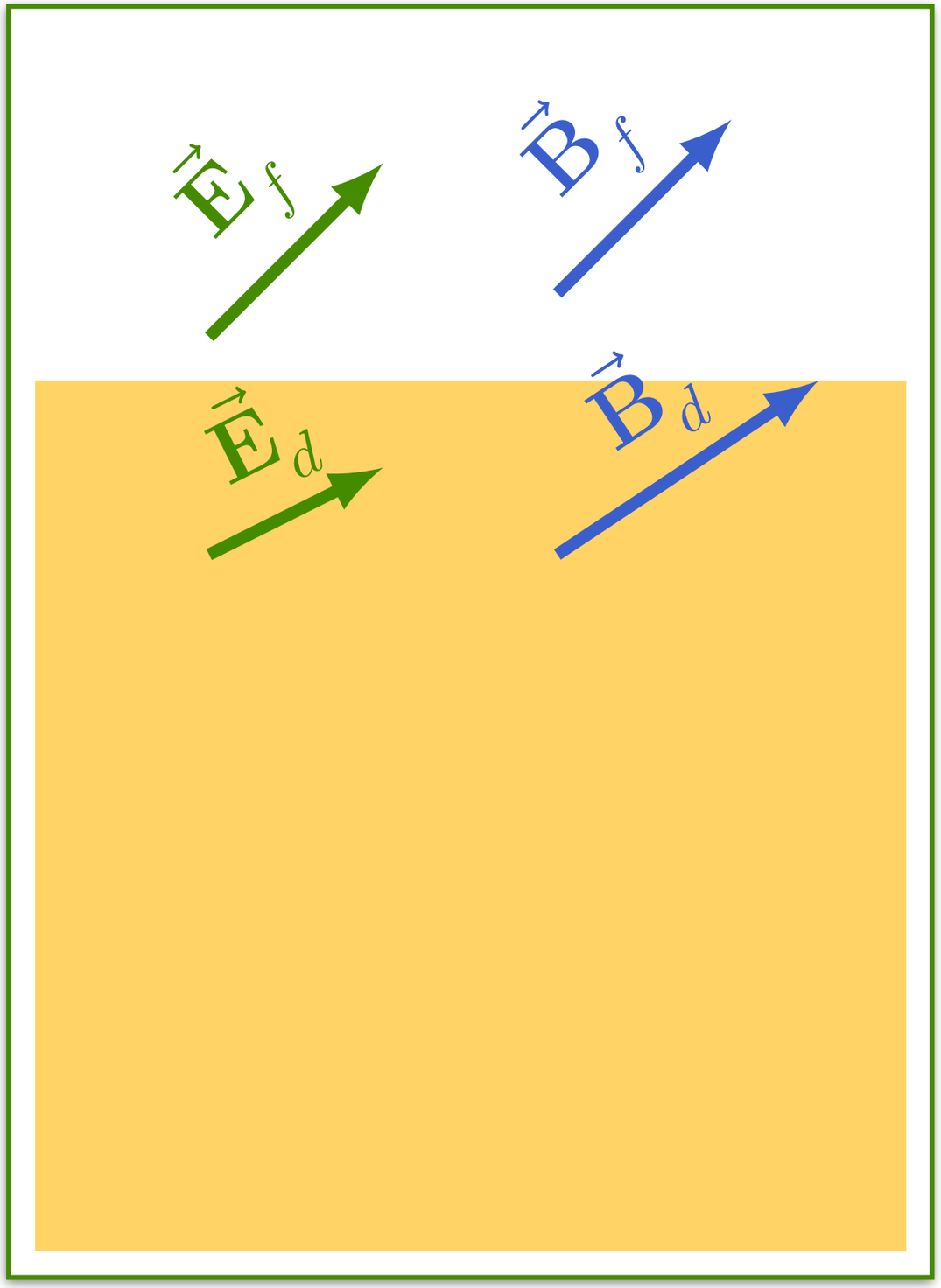
Meios lineares - fronteiras

$$E_{d\parallel} = E_{f\parallel}$$

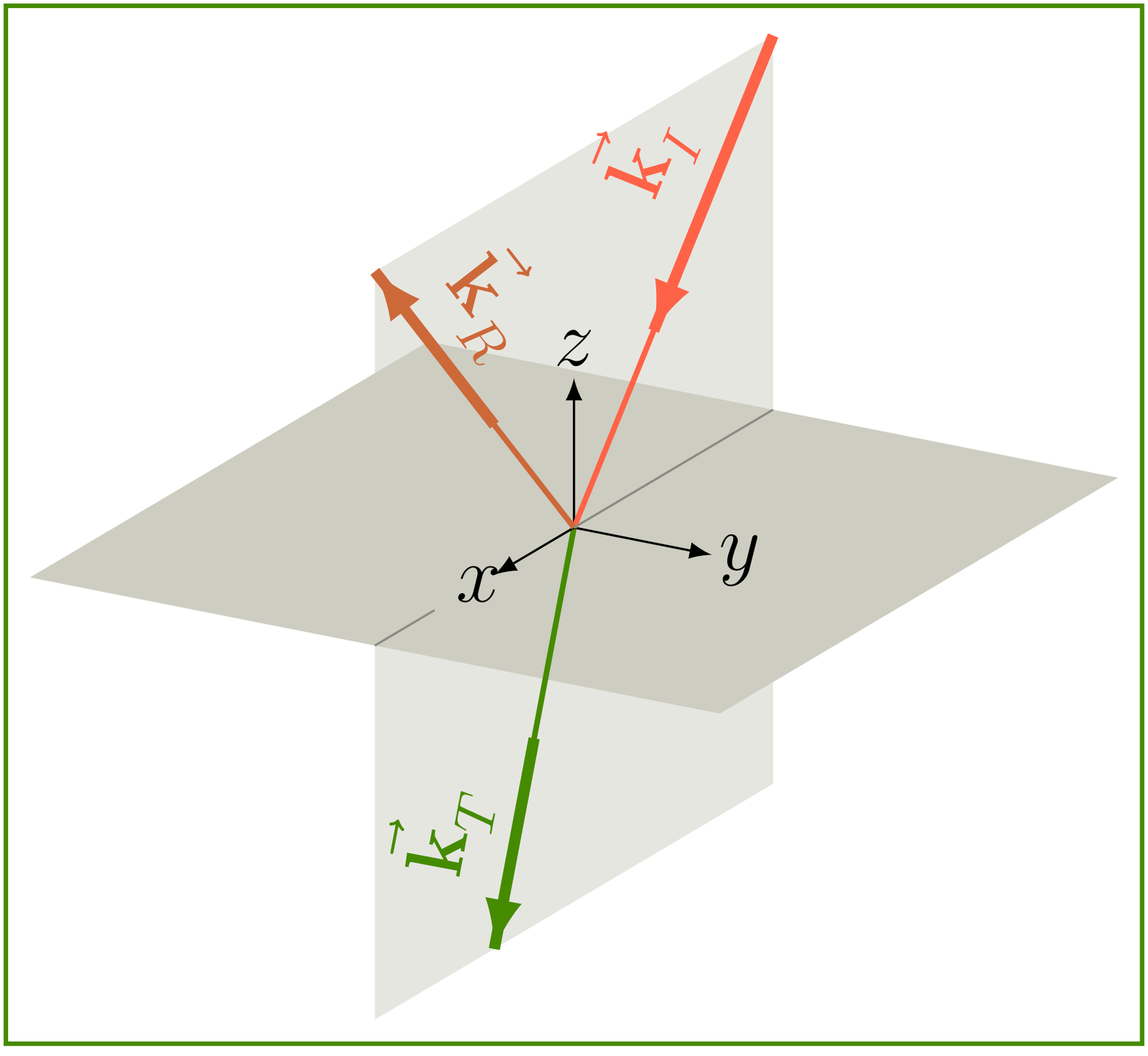
$$\epsilon E_{d\perp} = \epsilon_0 E_{f\perp}$$

$$\frac{1}{\mu} B_{d\parallel} = \frac{1}{\mu_0} B_{f\parallel}$$

$$B_{d\perp} = B_{f\perp}$$



Equações de Fresnel



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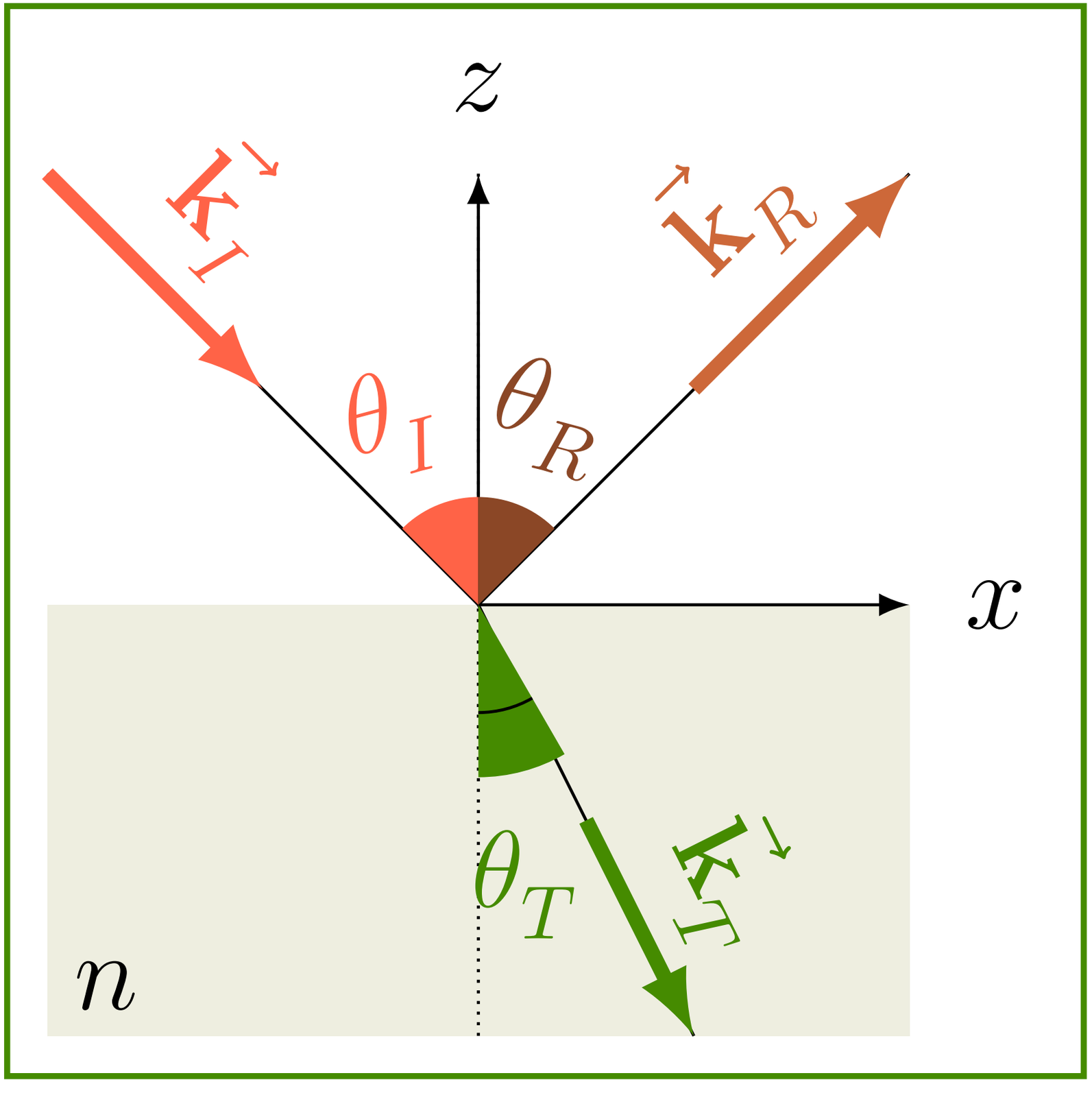
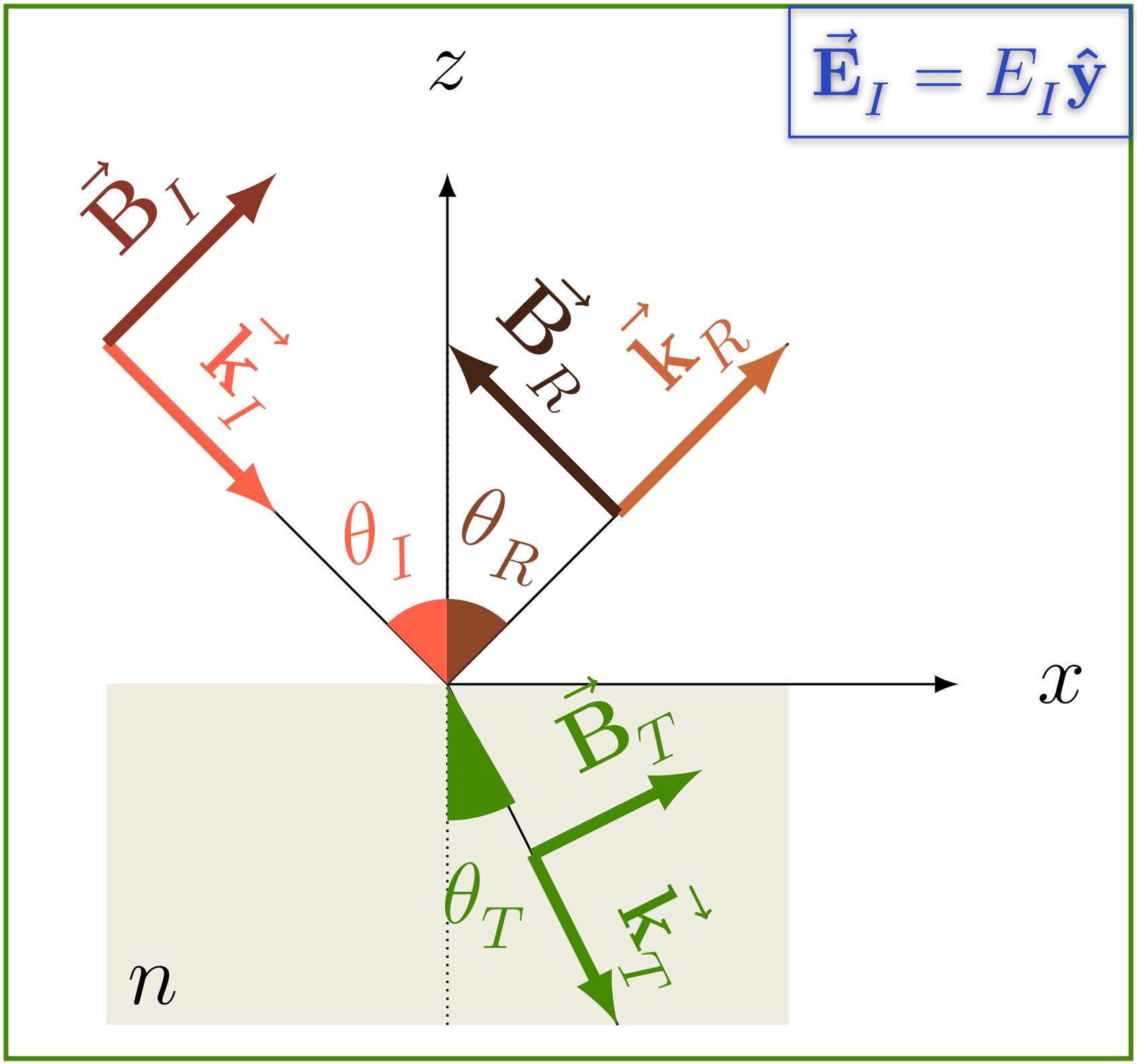


Equações de Fresnel

$$\vec{\mathbf{E}}_I = E_I \hat{\mathbf{y}}$$

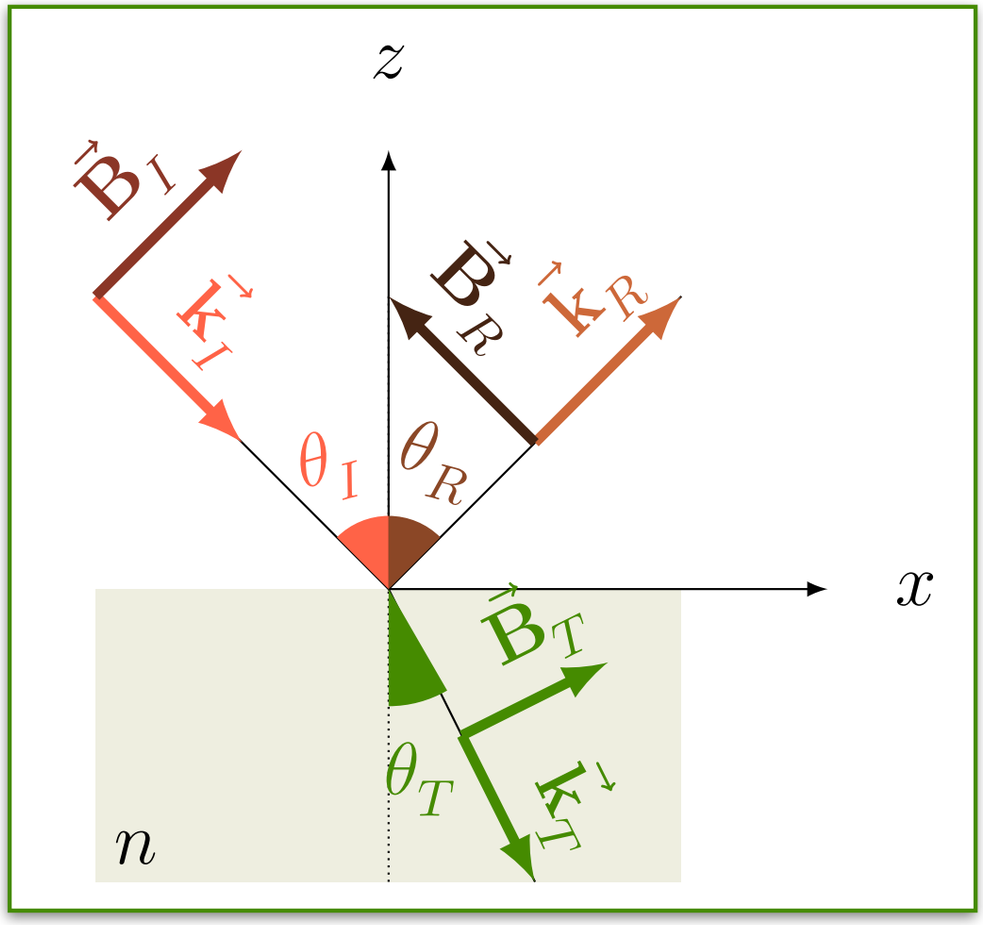


Equações de Fresnel

$$\vec{\mathbf{E}}_I(\vec{\mathbf{r}},t) = \vec{\mathbf{E}}_I \exp\Big(i(\vec{\mathbf{k}}\cdot\vec{\mathbf{r}} - \omega t)\Big)$$

$$\vec{\mathbf{E}}_R(\vec{\mathbf{r}},t) = \vec{\mathbf{E}}_R \exp\Big(i(\vec{\mathbf{k}}\cdot\vec{\mathbf{r}} - \omega t)\Big)$$

$$\vec{\mathbf{E}}_T(\vec{\mathbf{r}},t) = \vec{\mathbf{E}}_T \exp\Big(i(\vec{\mathbf{k}}\cdot\vec{\mathbf{r}} - \omega t)\Big)$$



$$\vec{\mathbf{B}}_I(\vec{\mathbf{r}},t) = \vec{\mathbf{B}}_I \exp\Big(i(\vec{\mathbf{k}}\cdot\vec{\mathbf{r}} - \omega t)\Big)$$

$$\vec{\mathbf{B}}_R(\vec{\mathbf{r}},t) = \vec{\mathbf{B}}_R \exp\Big(i(\vec{\mathbf{k}}\cdot\vec{\mathbf{r}} - \omega t)\Big)$$

$$\vec{\mathbf{B}}_T(\vec{\mathbf{r}},t) = \vec{\mathbf{B}}_T \exp\Big(i(\vec{\mathbf{k}}\cdot\vec{\mathbf{r}} - \omega t)\Big)$$

$$\boxed{\vec{\mathbf{E}}_I = E_I\hat{\mathbf{y}}}$$