

Física IV

06 outubro 2020

Equações de Maxwell
Espectro eletromagnético

Equações de Maxwell

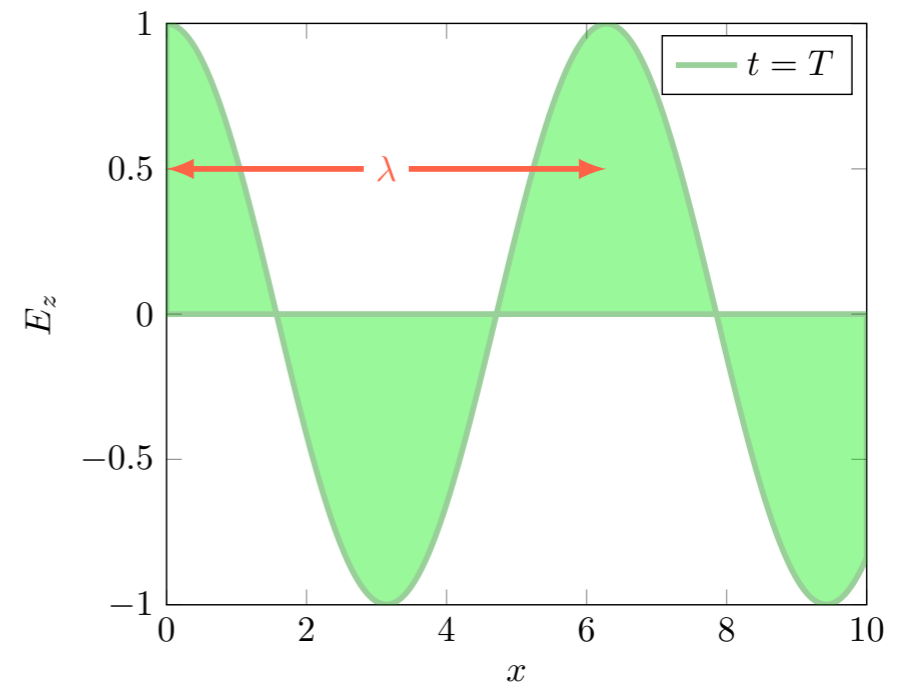
Radiação monocromática

$$\vec{E}(\vec{r}, t) = E_0 \cos(\vec{k} \cdot \vec{r} - \omega t) \hat{z}$$

$$\omega = ck \quad \lambda = cT$$

$$k = \frac{2\pi}{\lambda} \quad \omega = \frac{2\pi}{T}$$

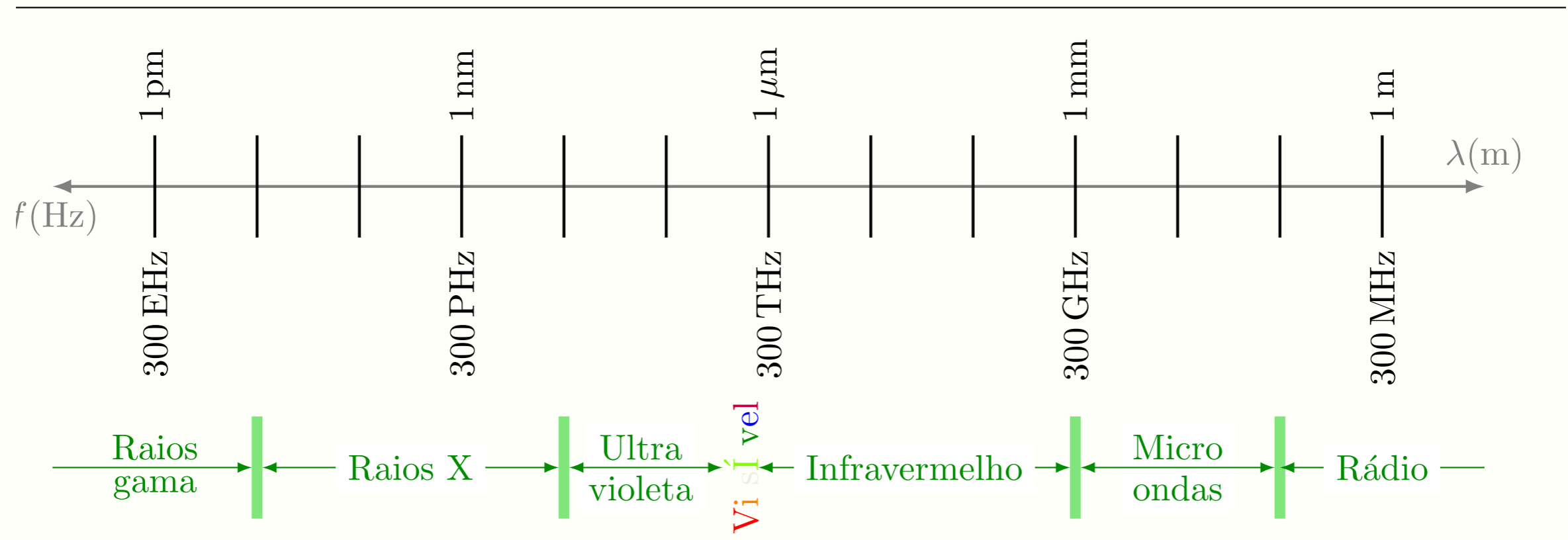
$$f = \frac{1}{T} \quad \omega = 2\pi f$$



Equações de Maxwell

Espaço livre

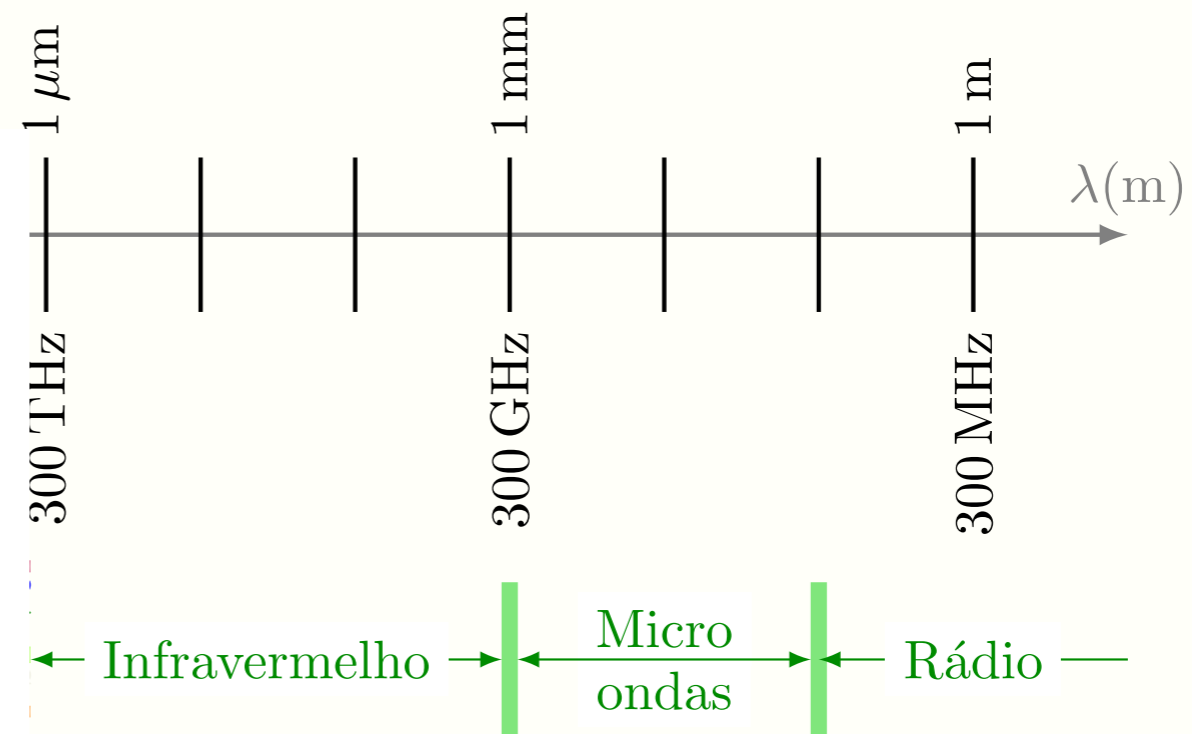
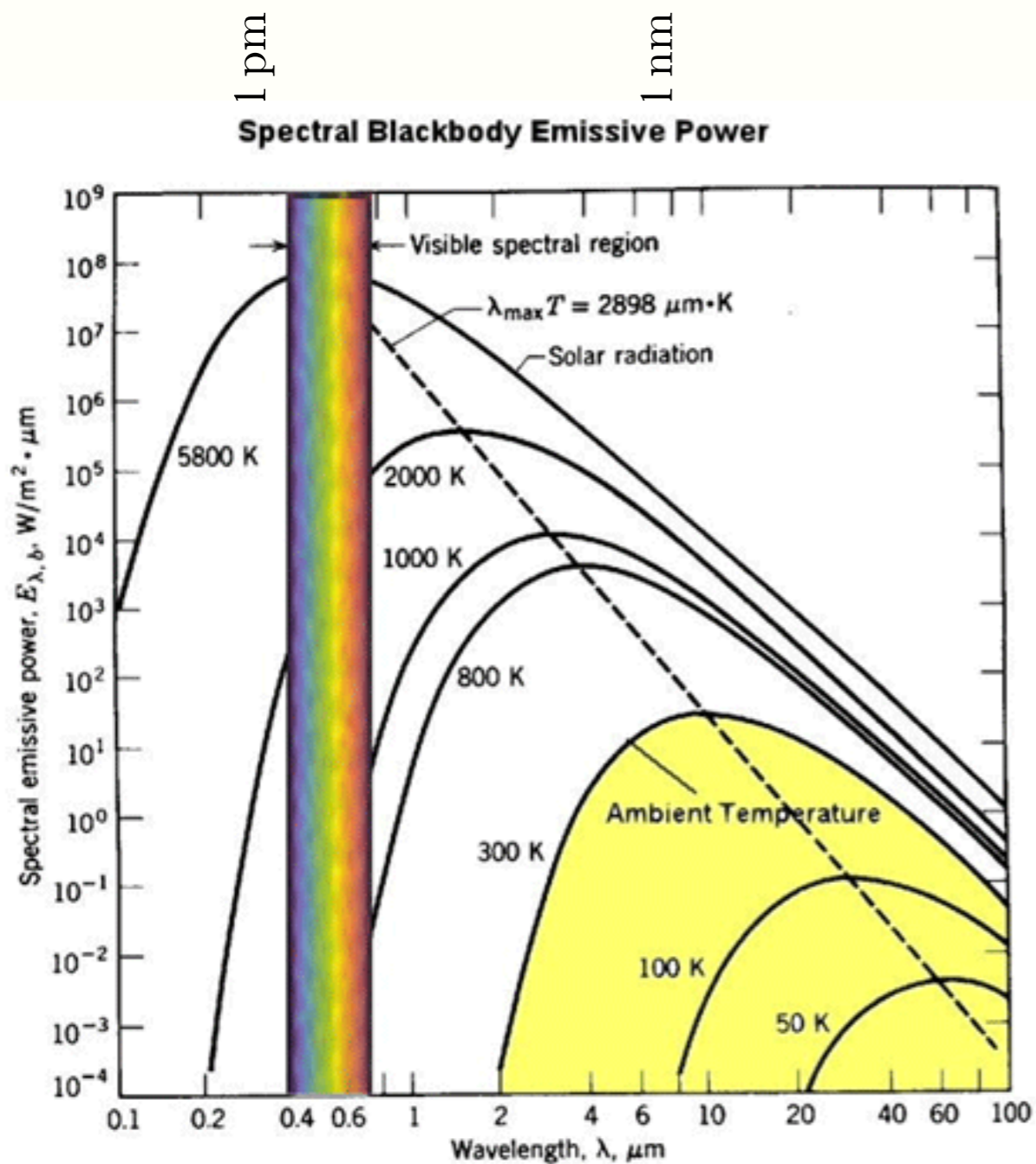
Espectro eletromagnético



Equações de Maxwell

Espaço livre

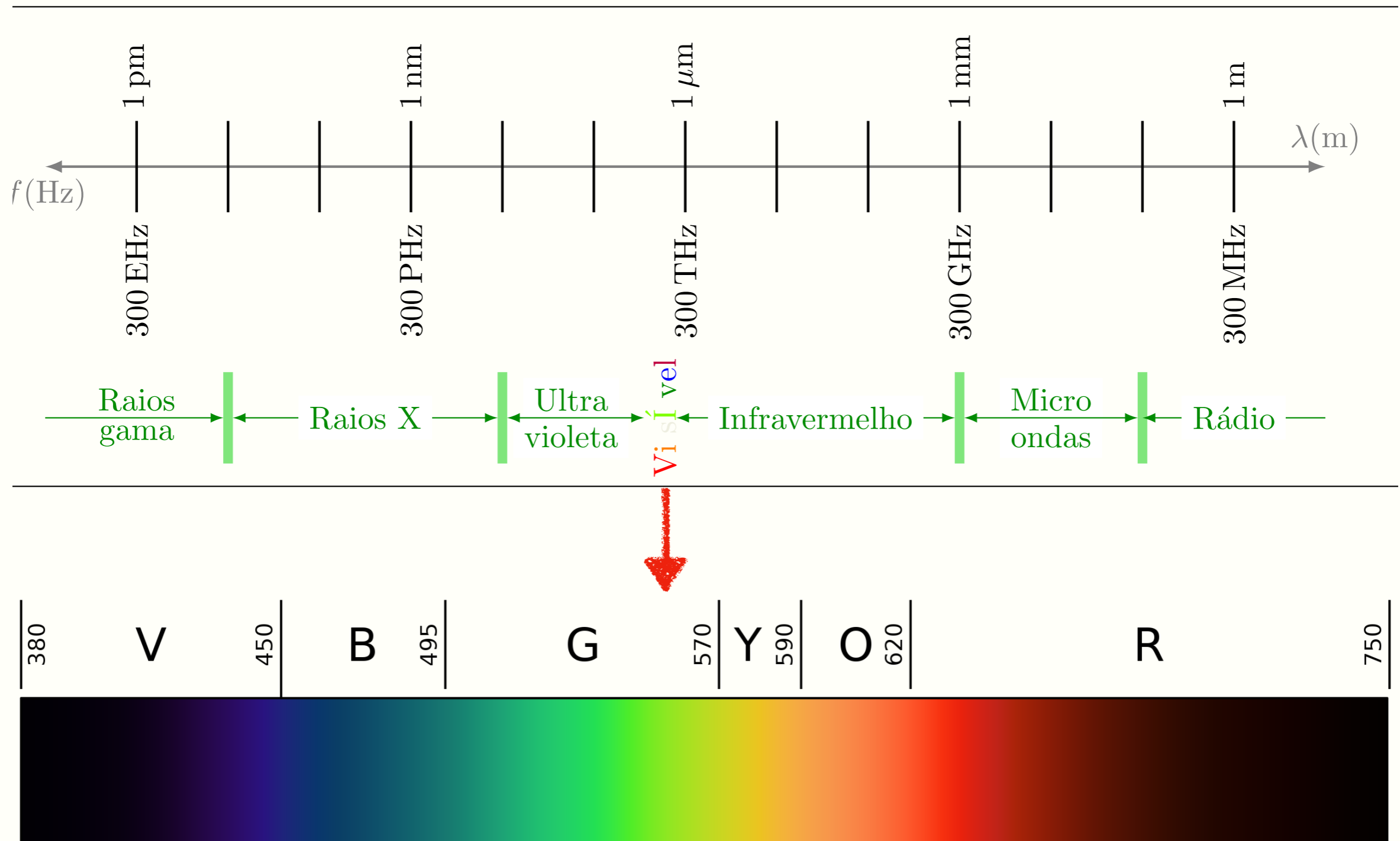
Espectro eletromagnético



Equações de Maxwell

Espaço livre

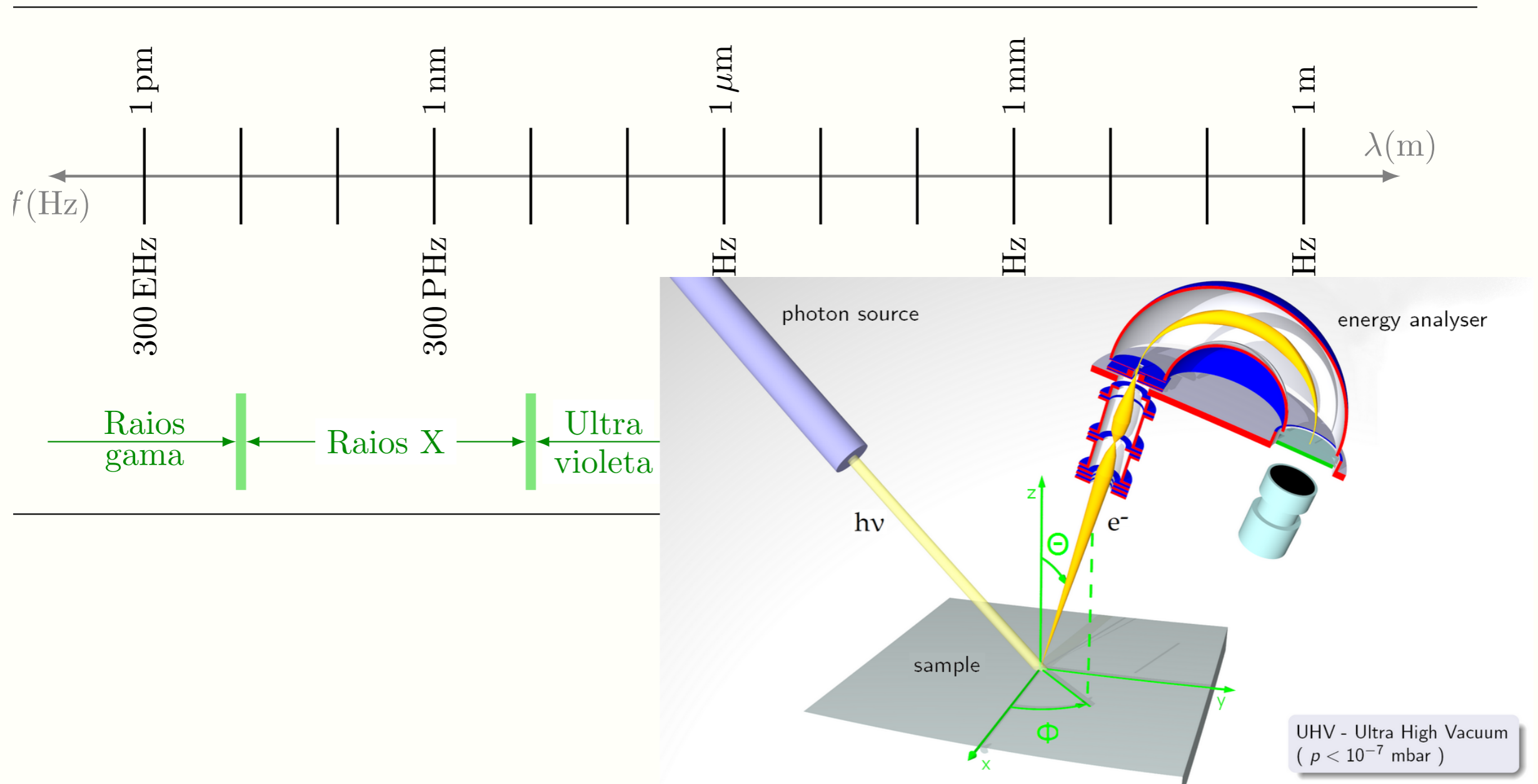
Espectro eletromagnético



Equações de Maxwell

Espaço livre

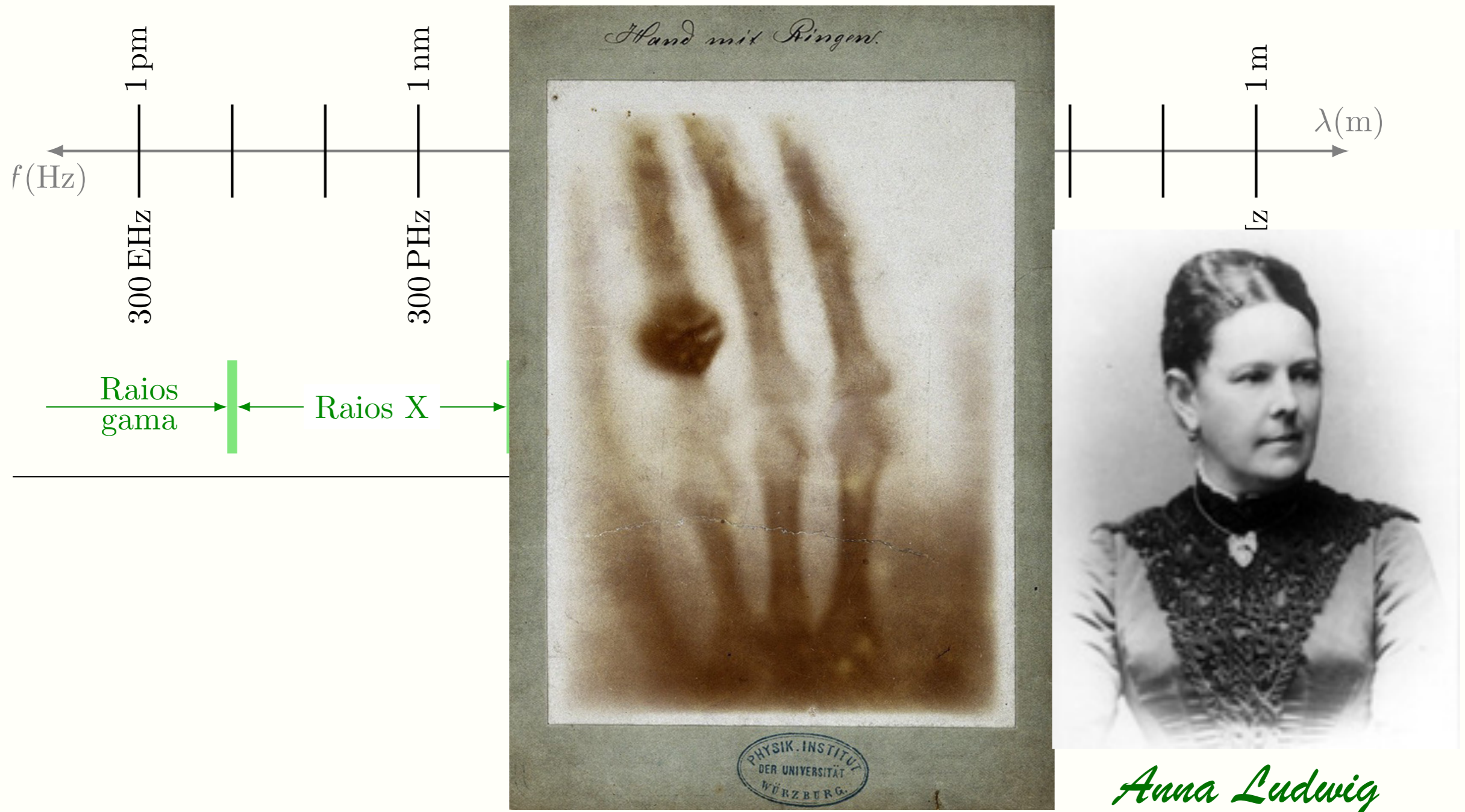
Espectro eletromagnético



Equações de Maxwell

Espaço livre

Espectro eletromagnético

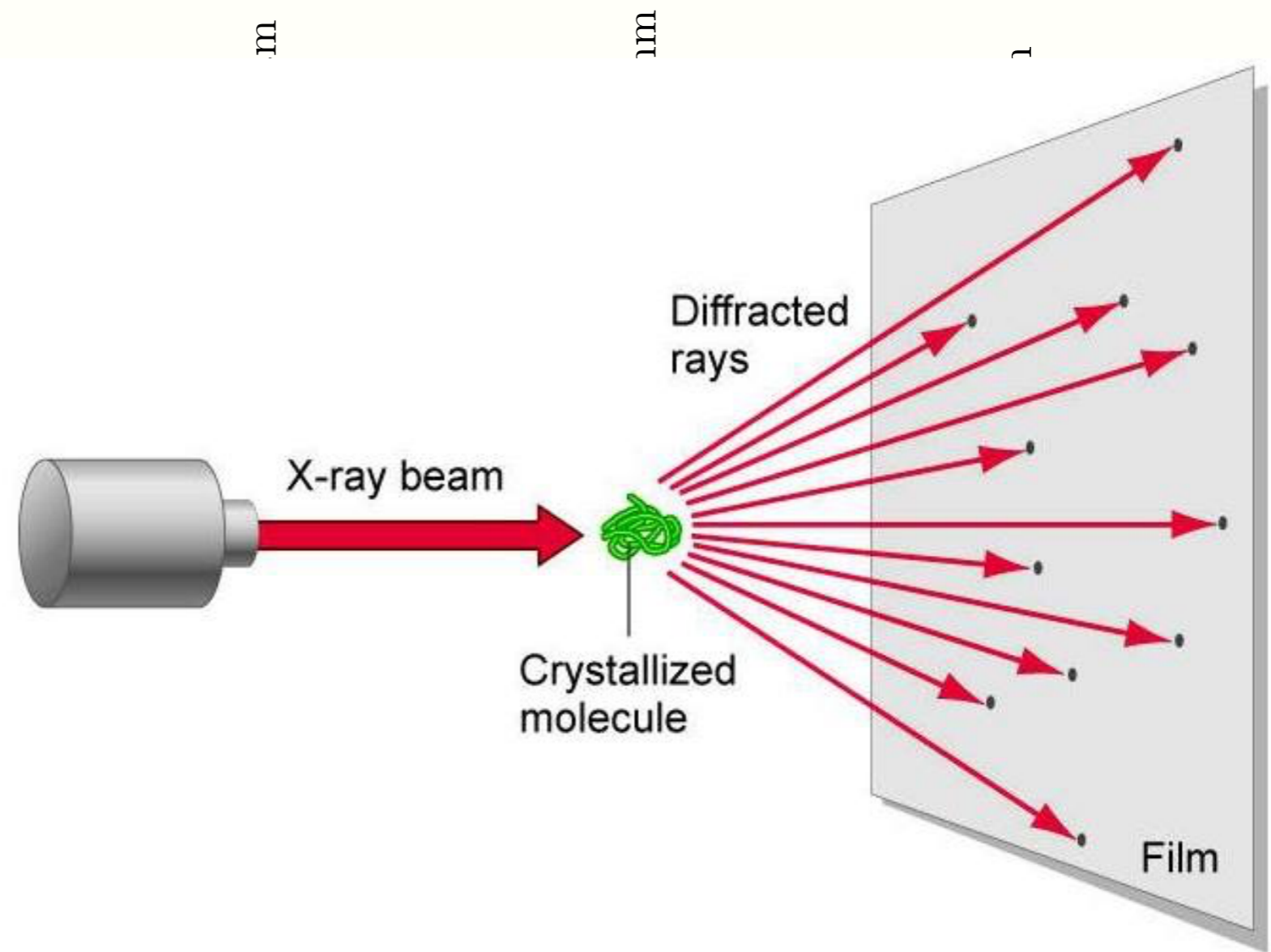
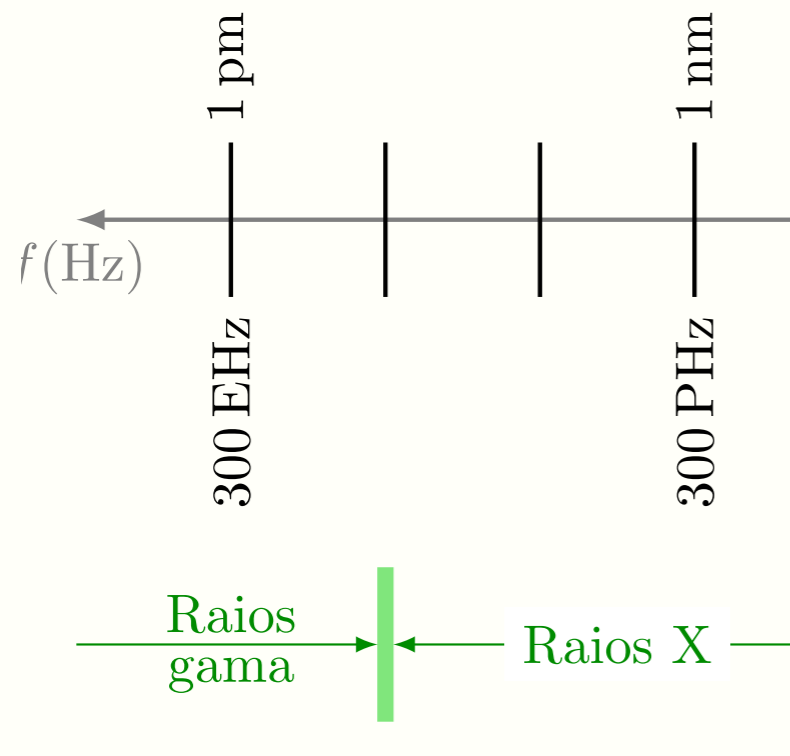


Anna Ludwig

Equações de Maxwell

Espaço livre

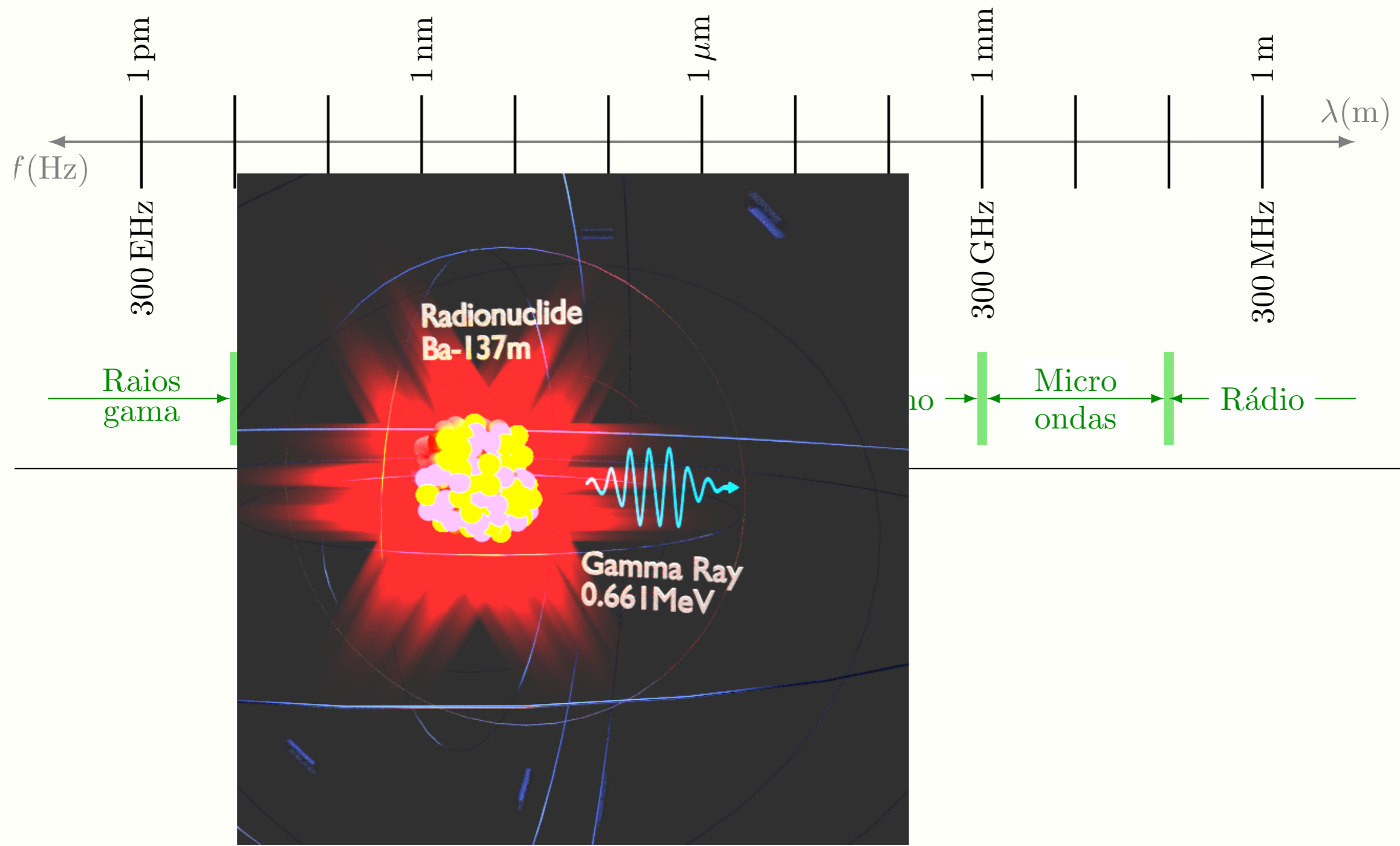
Espectro eletromagnético



Equações de Maxwell

Espaço livre

Espectro eletromagnético



Equações de Maxwell

Campos elétrico e magnético

$$\vec{E}(\vec{r}, t) = E_0 \cos(kx - \omega t) \hat{z}$$

$$\vec{\nabla} \times \vec{E} = - \frac{\partial \vec{B}}{\partial t}$$

Equações de Maxwell

Campos elétrico e magnético

$$\vec{E}(\vec{r}, t) = E_0 \cos(kx - \omega t) \hat{z}$$

$$\vec{\nabla} \times \vec{E} = - \frac{\partial \vec{B}}{\partial t}$$

$$\frac{\partial E_z}{\partial y} = - \frac{\partial B_x}{\partial t}$$

$$\Rightarrow B_x = 0$$

Equações de Maxwell

Campos elétrico e magnético

$$\vec{E}(\vec{r}, t) = E_0 \cos(kx - \omega t) \hat{z}$$

$$\vec{\nabla} \times \vec{E} = -\frac{\partial \vec{B}}{\partial t}$$

$$\left(\vec{\nabla} \times \vec{E} \right)_x = \frac{\partial E_z}{\partial y} - \frac{\partial E_y}{\partial z}$$

$$\frac{\partial E_z}{\partial y} = -\frac{\partial B_x}{\partial t}$$

$$\Rightarrow B_x = 0$$

Equações de Maxwell

Campos elétrico e magnético

$$\vec{E}(\vec{r}, t) = E_0 \cos(kx - \omega t) \hat{z}$$

$$\vec{\nabla} \times \vec{E} = - \frac{\partial \vec{B}}{\partial t}$$

$$\left(\vec{\nabla} \times \vec{E} \right)_y = \frac{\partial E_x}{\partial z} - \frac{\partial E_z}{\partial x}$$

$$\frac{\partial E_z}{\partial x} = \frac{\partial B_y}{\partial t}$$

$$\Rightarrow \frac{\partial B_y}{\partial t} = -kE_0 \sin(kx - \omega t)$$

Equações de Maxwell

Campos elétrico e magnético

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$$\Rightarrow \frac{\partial B_y}{\partial t} = -kE_0 \sin(kx - \omega t)$$

$$B_y = -\frac{k}{\omega} E_0 \cos(kx - \omega t)$$

Equações de Maxwell

Campos elétrico e magnético

$$\vec{E}(\vec{r}, t) = E_0 \cos(kx - \omega t) \hat{z}$$

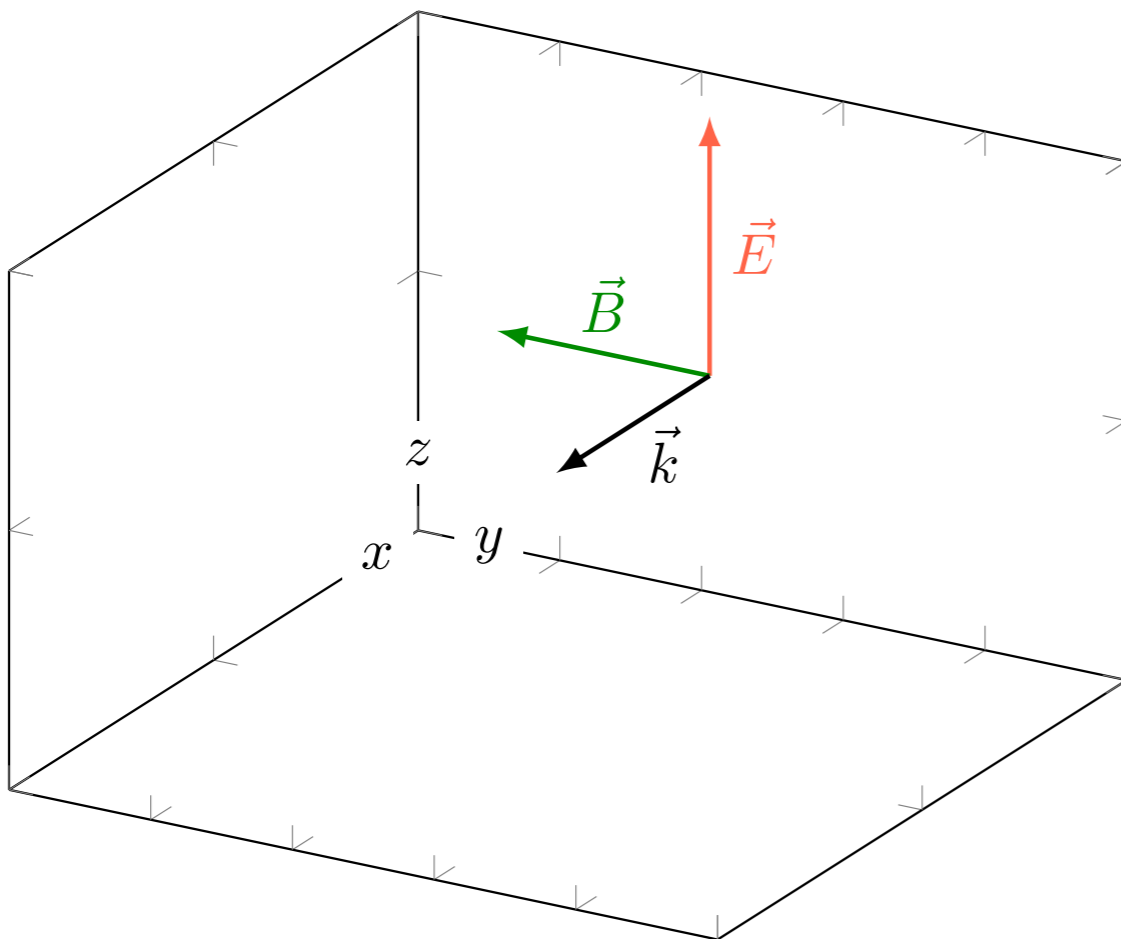
$$B_y = -\frac{k}{\omega} E_0 \cos(kx - \omega t) = -\frac{E_z}{c}$$

Equações de Maxwell

Campos elétrico e magnético

$$\vec{E}(\vec{r}, t) = E_0 \cos(kx - \omega t) \hat{z}$$

$$B_y = -\frac{k}{\omega} E_0 \cos(kx - \omega t) = -\frac{E_z}{c}$$



Pratique o que aprendeu

$$\vec{B}(\vec{r}, t) = \cos(2\pi(x + 2y) - \omega t) \hat{z}$$

$$\omega, \quad \vec{k}, \quad \vec{E} = ?$$

$$\omega, \vec{k}, \vec{E} = ?$$

Pratique o que aprendeu

$$\vec{B}(\vec{r}, t) = \cos(2\pi(x + 2y) - \omega t) \hat{z}$$

$$\vec{k} \cdot \vec{r} = 2\pi x + 4\pi y$$

$$\omega, \vec{k}, \vec{E} = ?$$

Pratique o que aprendeu

$$\vec{B}(\vec{r}, t) = \cos(2\pi(x + 2y) - \omega t) \hat{z}$$

$$\vec{k} \cdot \vec{r} = 2\pi x + 4\pi y$$

$$\Rightarrow \begin{cases} k_x = 2\pi \\ k_y = 4\pi \end{cases}$$

$$\omega, \vec{k}, \vec{E} = ?$$

Pratique o que aprendeu

$$\vec{B}(\vec{r}, t) = \cos(2\pi(x + 2y) - \omega t) \hat{x}$$

$$\vec{k} \cdot \vec{r} = 2\pi x + 4\pi y \quad \Rightarrow \quad \begin{cases} k_x = 2\pi \\ k_y = 4\pi \end{cases}$$

$$k = \sqrt{(2\pi)^2 + (4\pi)^2} = 2\pi\sqrt{5}$$

$$\omega, \vec{k}, \vec{E} = ?$$

Pratique o que aprendeu

$$\vec{B}(\vec{r}, t) = \cos(2\pi(x + 2y) - \omega t) \hat{z}$$

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$$k = \sqrt{(2\pi)^2 + (4\pi)^2} = 2\pi\sqrt{5} \quad \Rightarrow \quad \omega = 2\pi\sqrt{5}c$$

$$\omega, \vec{k}, \vec{E} = ?$$

Pratique o que aprendeu

$$\vec{B}(\vec{r}, t) = \cos(2\pi(x + 2y) - \omega t) \hat{z}$$

$$\vec{\nabla} \times \vec{B} = \mu_0 \epsilon_0 \frac{\partial \vec{E}}{\partial t}$$

$$\vec{k} = 2\pi \hat{x} + 4\pi \hat{y}$$

$$\omega = 2\pi \sqrt{5} c$$

$$\omega, \vec{k}, \vec{E} = ?$$

Pratique o que aprendeu

$$\vec{B}(\vec{r}, t) = \cos(2\pi(x + 2y) - \omega t) \hat{z}$$

$$\vec{\nabla} \times \vec{B} = \mu_0 \epsilon_0 \frac{\partial \vec{E}}{\partial t}$$

$$\vec{\nabla} \times \vec{B} = \left(\frac{\partial B_z}{\partial y} - \frac{\partial B_y}{\partial z} \right) \hat{x} + \left(\frac{\partial B_x}{\partial z} - \frac{\partial B_z}{\partial x} \right) \hat{y} + \left(\frac{\partial B_y}{\partial x} - \frac{\partial B_x}{\partial y} \right) \hat{z}$$

$$\vec{k} = 2\pi \hat{x} + 4\pi \hat{y}$$

$$\omega = 2\pi \sqrt{5} c$$

$$\omega, \vec{k}, \vec{E} = ?$$

Pratique o que aprendeu

$$\vec{B}(\vec{r}, t) = \cos(2\pi(x + 2y) - \omega t) \hat{z}$$

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$$\vec{\nabla} \times \vec{B} = \mu_0\epsilon_0 \frac{\partial \vec{E}}{\partial t}$$

$$\vec{\nabla} \times \vec{B} = \left(\frac{\partial B_z}{\partial y} - \frac{\partial B_y}{\partial z} \right) \hat{x} + \left(\frac{\partial B_x}{\partial z} - \frac{\partial B_z}{\partial x} \right) \hat{y} + \left(\frac{\partial B_y}{\partial x} - \frac{\partial B_x}{\partial y} \right) \hat{z}$$

$$-2\pi \sin(2\pi(x + 2y) - \omega t) (2\hat{x} - \hat{y}) = \mu_0\epsilon_0 \frac{\partial \vec{E}}{\partial t}$$

$$\omega, \vec{k}, \vec{E} = ?$$

Pratique o que aprendeu

$$\vec{B}(\vec{r}, t) = \cos(2\pi(x + 2y) - \omega t) \hat{z}$$

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$$-2\pi \sin(2\pi(x + 2y) - \omega t) (2\hat{x} - \hat{y}) = \mu_0\epsilon_0 \frac{\partial \vec{E}}{\partial t}$$

$$\vec{E} = -\frac{2\pi}{\omega\mu_0\epsilon_0} \cos(2\pi(x + 2y) - \omega t) (2\hat{x} - \hat{y})$$

$$\omega, \quad \vec{k}, \quad \vec{E} = ?$$

Pratique o que aprendeu

$$\vec{B}(\vec{r}, t) = \cos(2\pi(x + 2y) - \omega t) \hat{z}$$

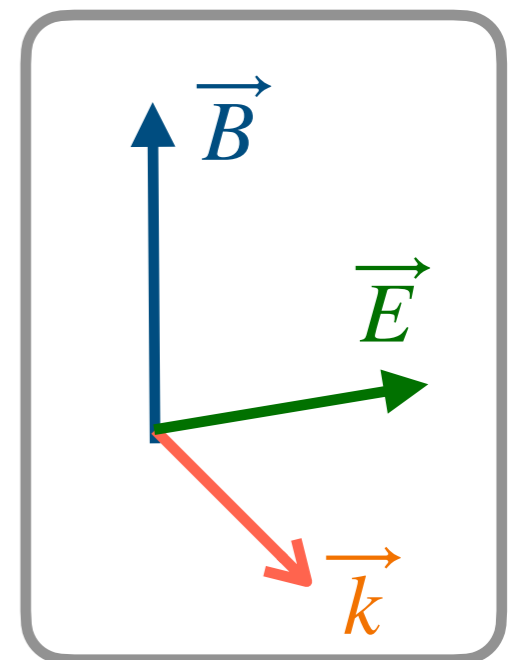
$$\vec{\nabla} \times \vec{B} = \mu_0 \epsilon_0 \frac{\partial \vec{E}}{\partial t}$$

$$-2\pi \sin(2\pi(x + 2y) - \omega t) (2\hat{x} - \hat{y}) = \mu_0 \epsilon_0 \frac{\partial \vec{E}}{\partial t}$$

$$\vec{E} = -c \cos(2\pi(x + 2y) - \omega t) \frac{2\hat{x} - \hat{y}}{\sqrt{5}}$$

$$\vec{k} = 2\pi\hat{x} + 4\pi\hat{y}$$

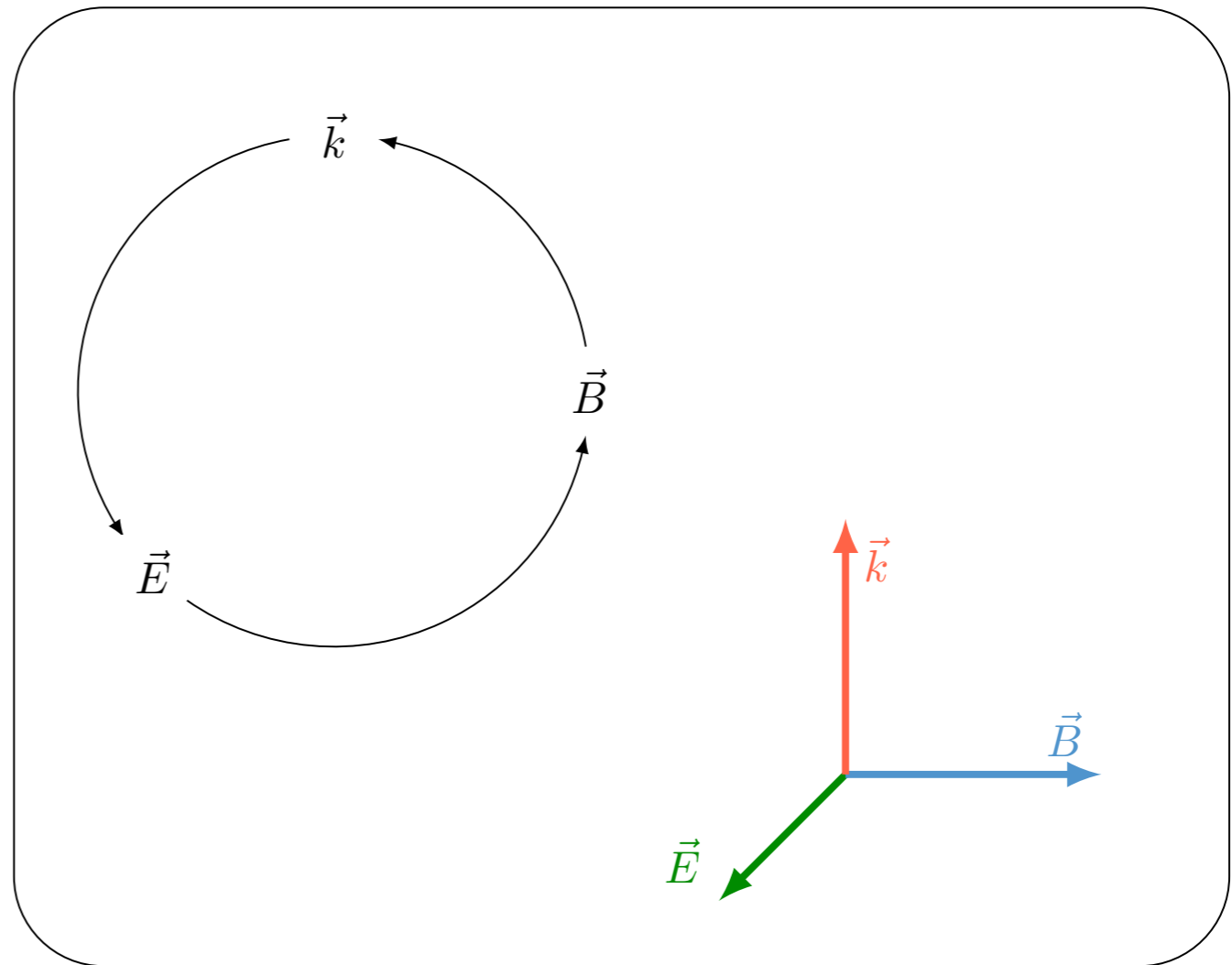
$$\omega = 2\pi\sqrt{5}c$$



Equações de Maxwell

Campos elétrico e magnético

$$c\vec{B} = \hat{k} \times \vec{E}$$

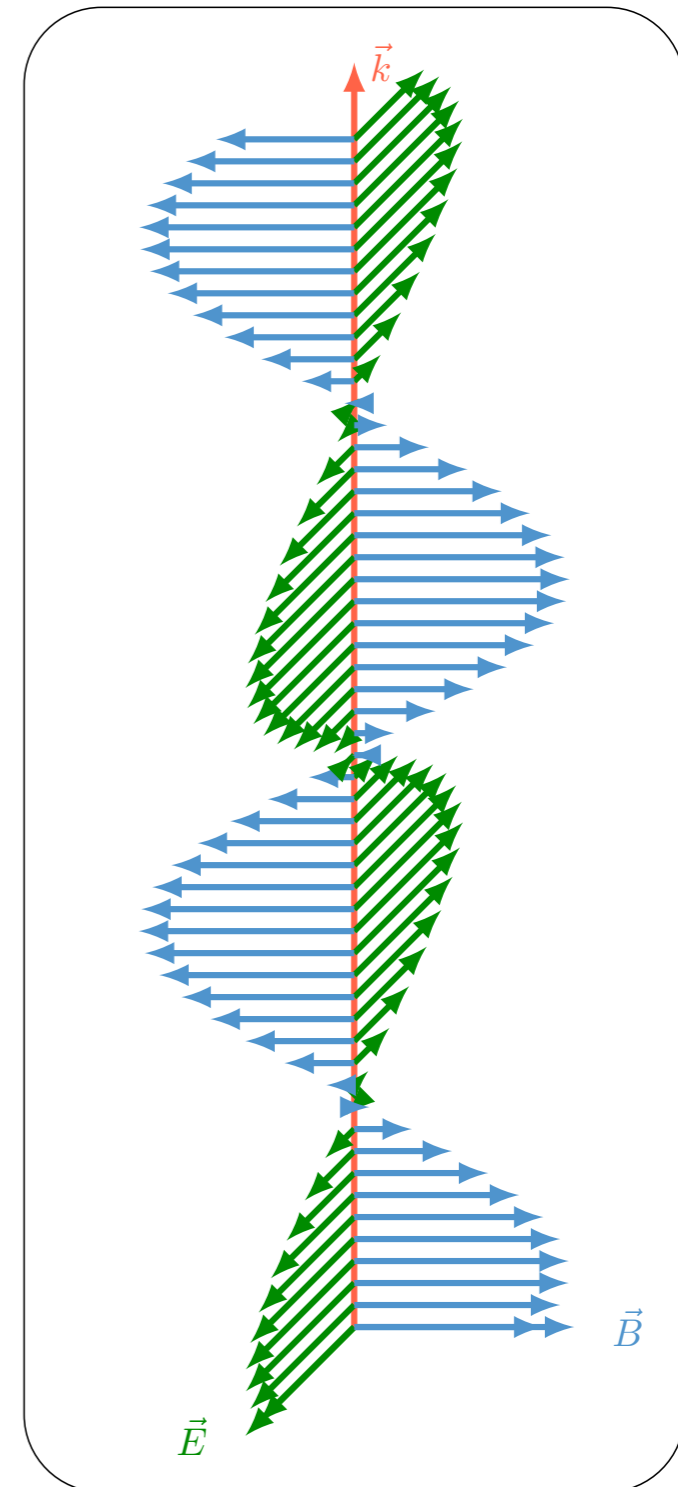


Equações de Maxwell

Campos elétrico e magnético

$$\vec{E}(\vec{r}, t) = A \cos(kz - \omega t) \hat{x}$$

$$\vec{B}(\vec{r}, t) = \frac{A}{c} \cos(kz - \omega t) \hat{y}$$

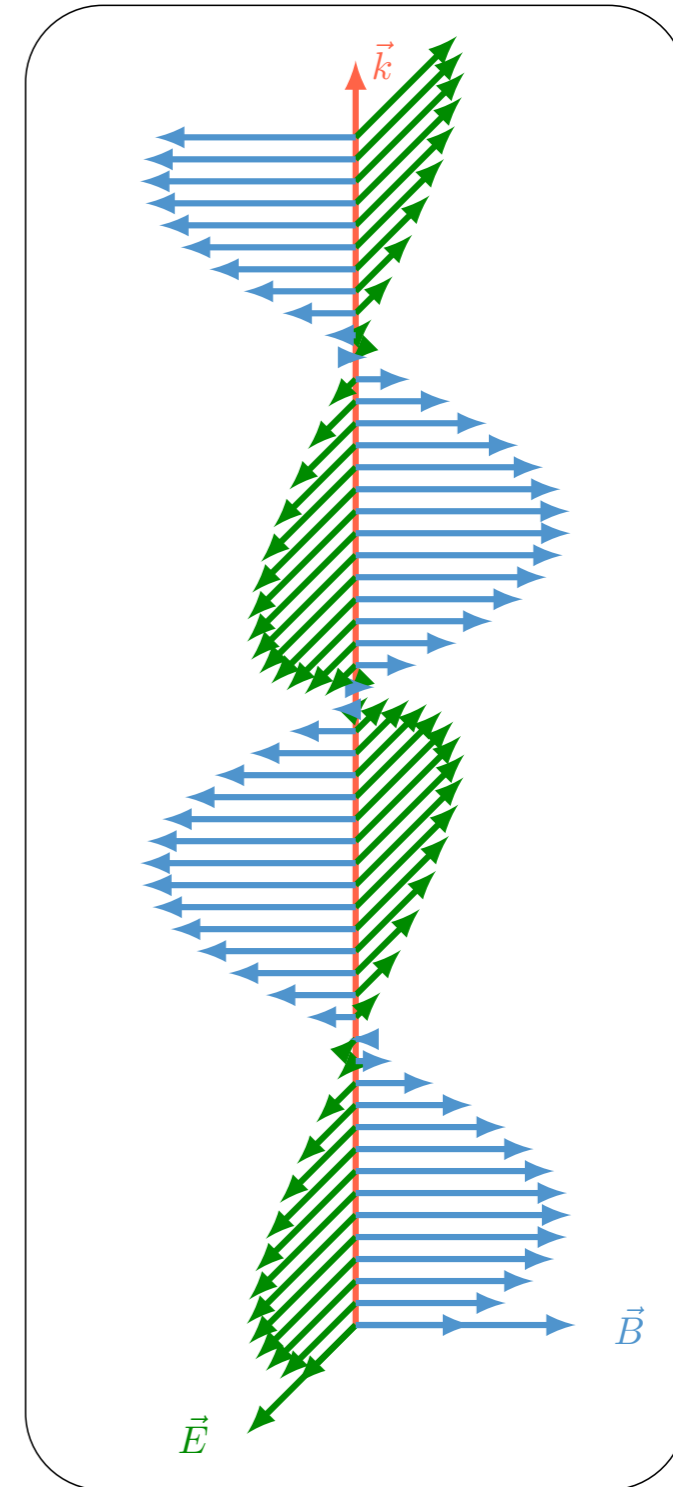


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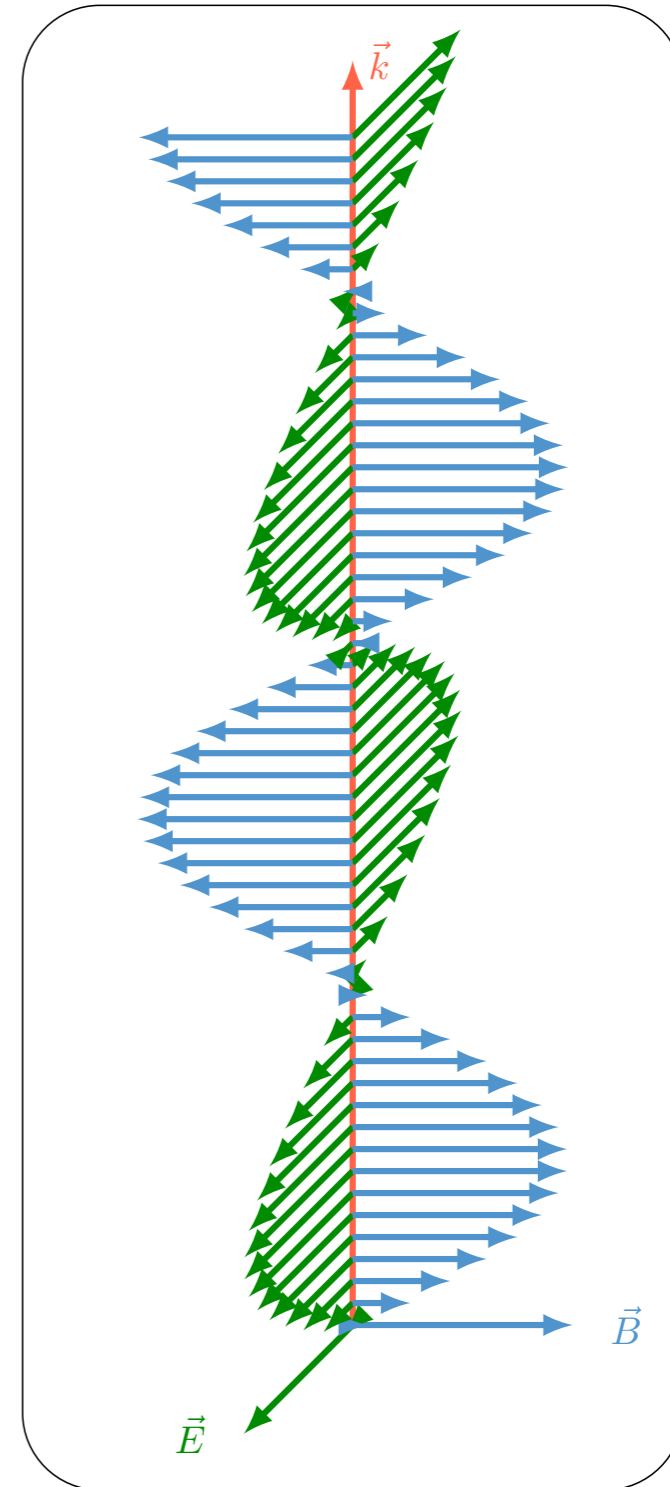


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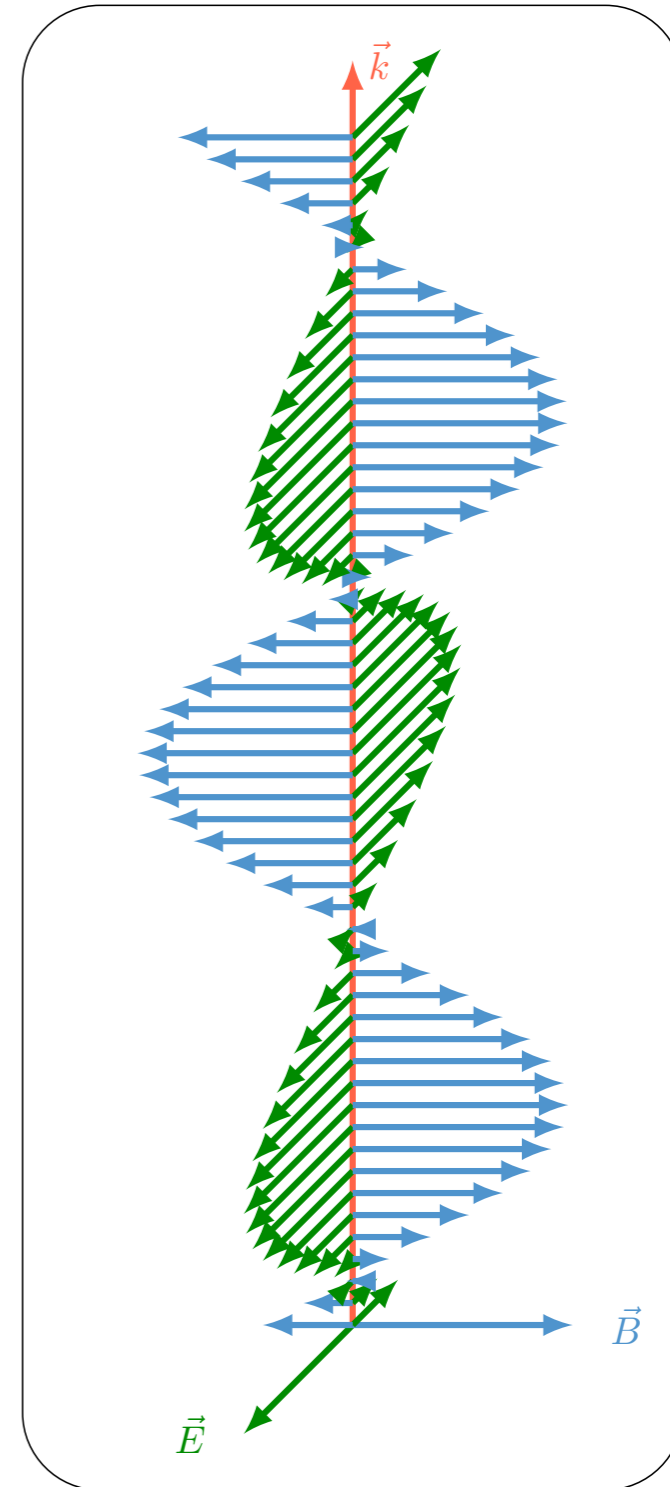


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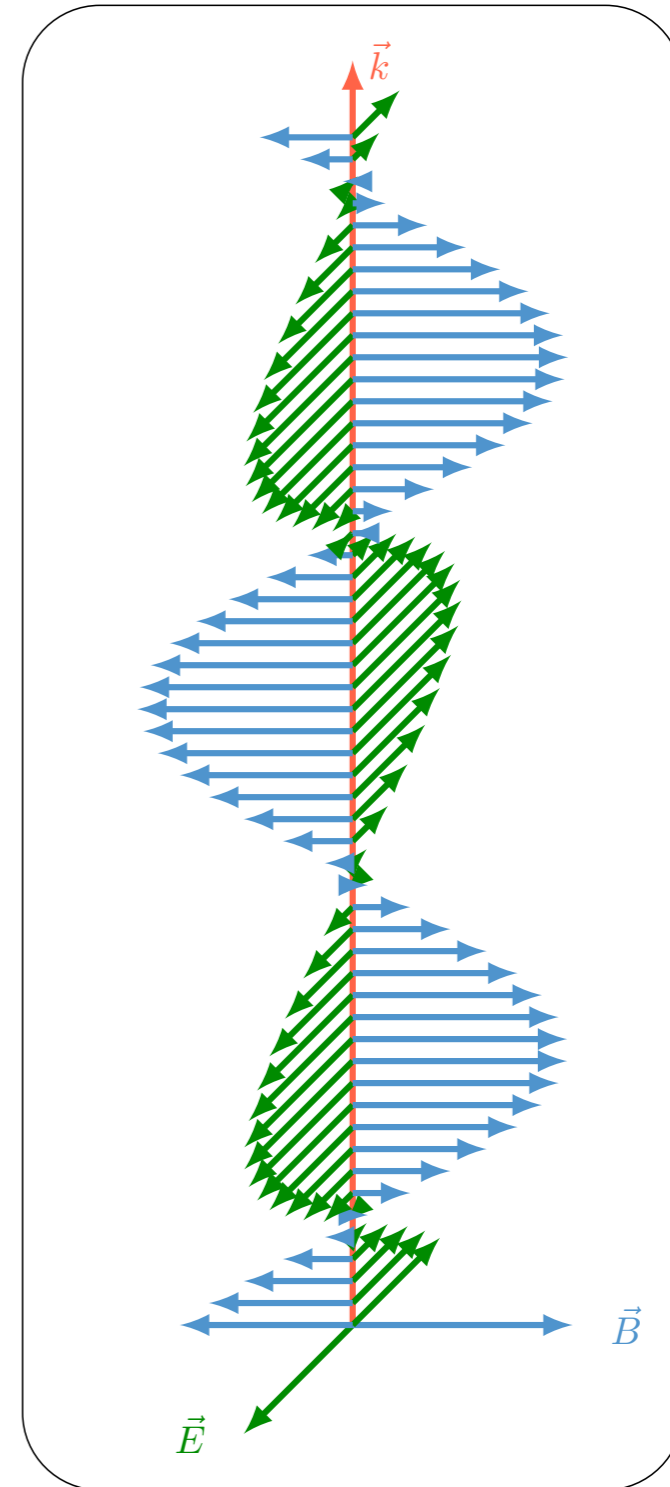


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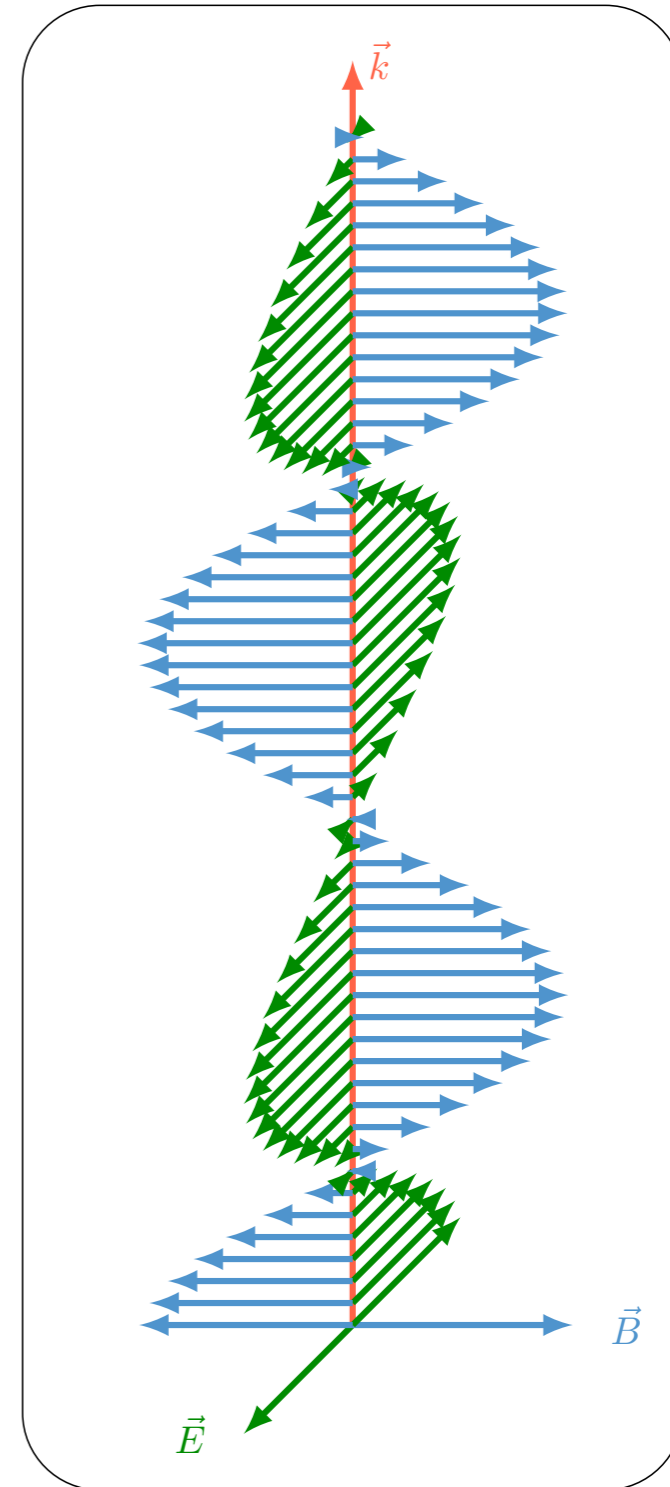


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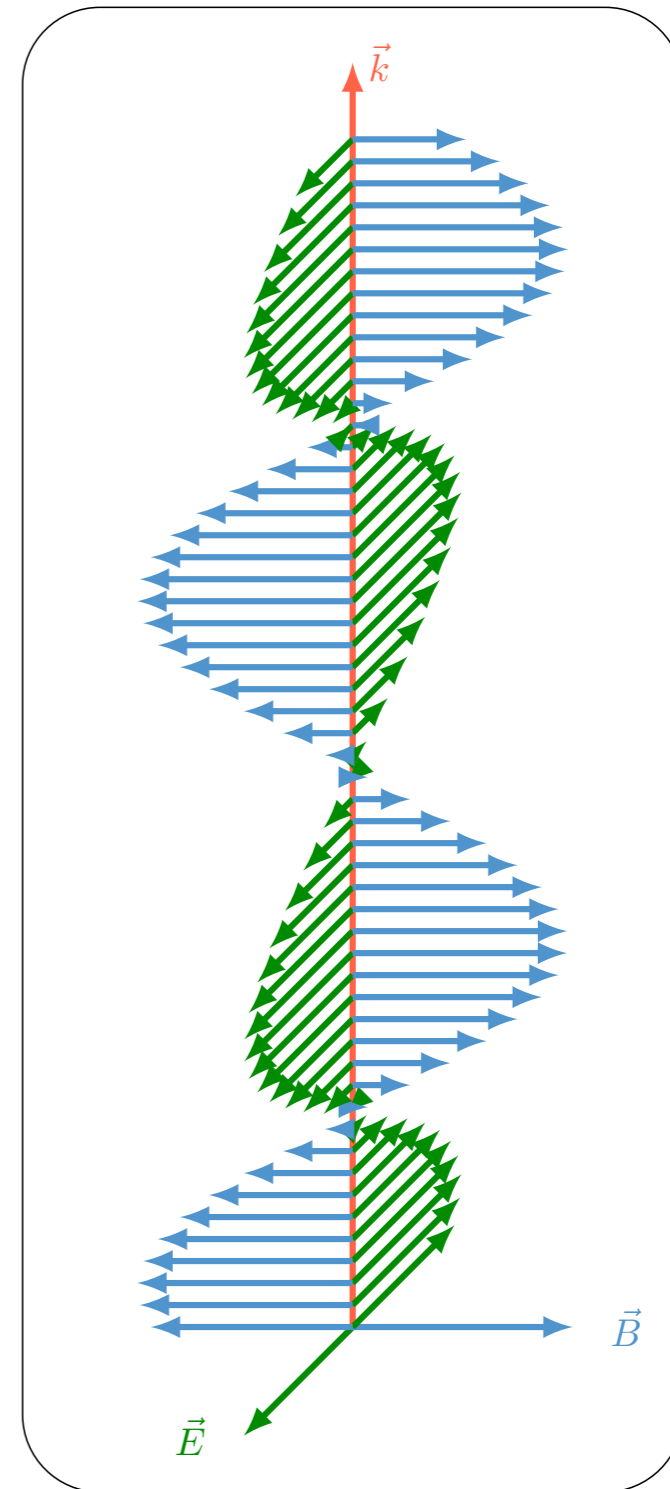


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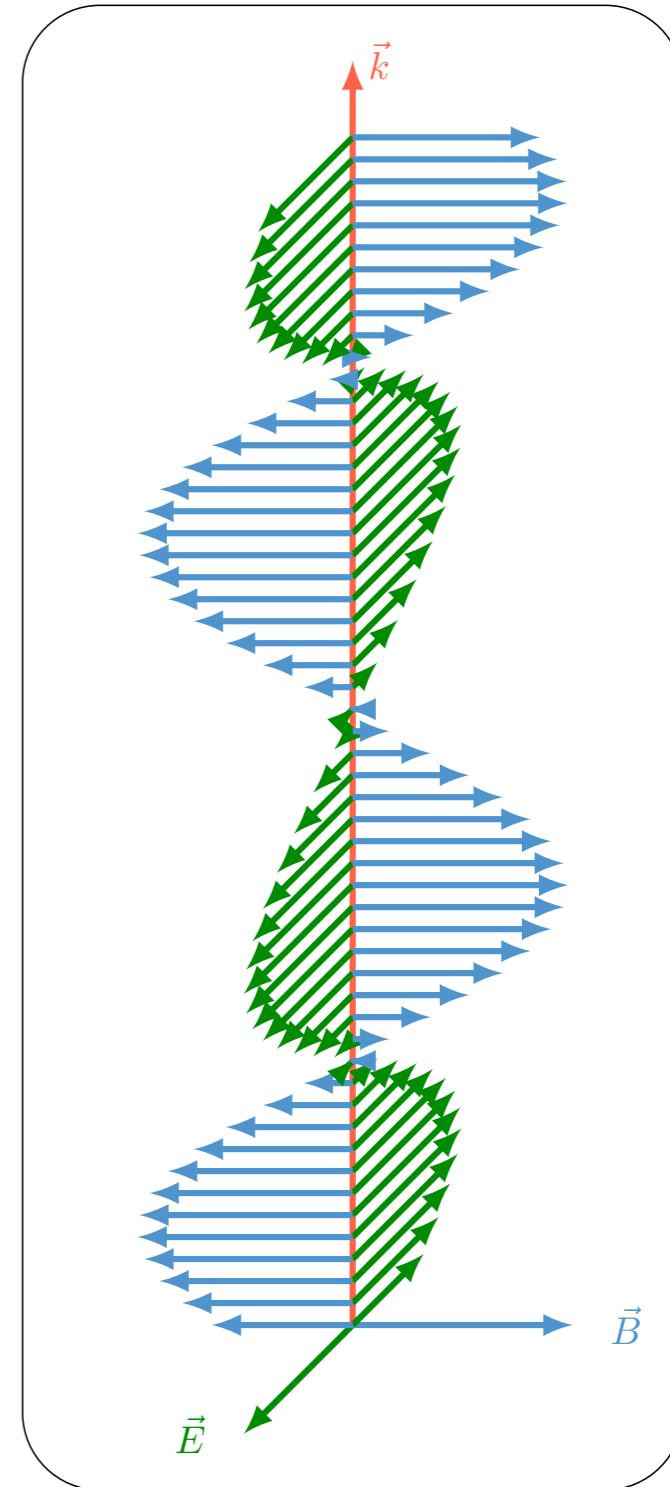


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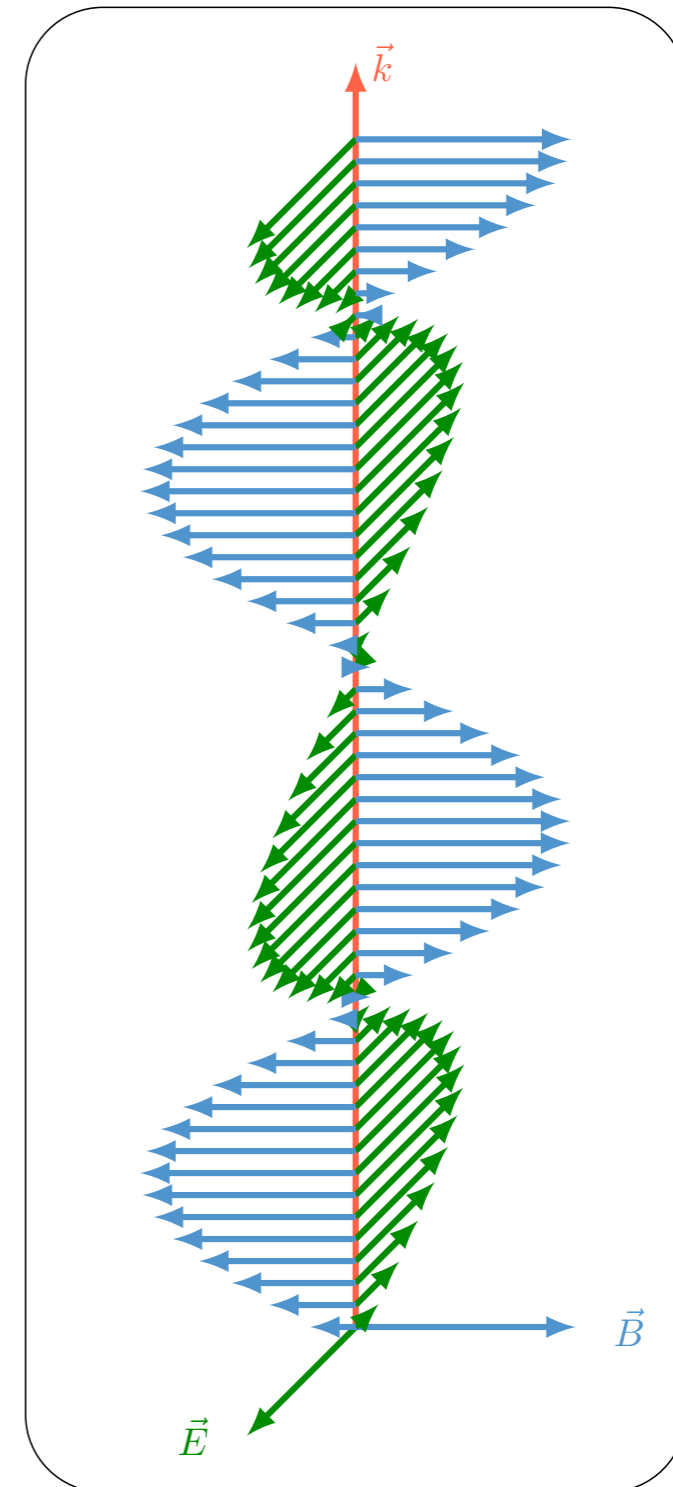


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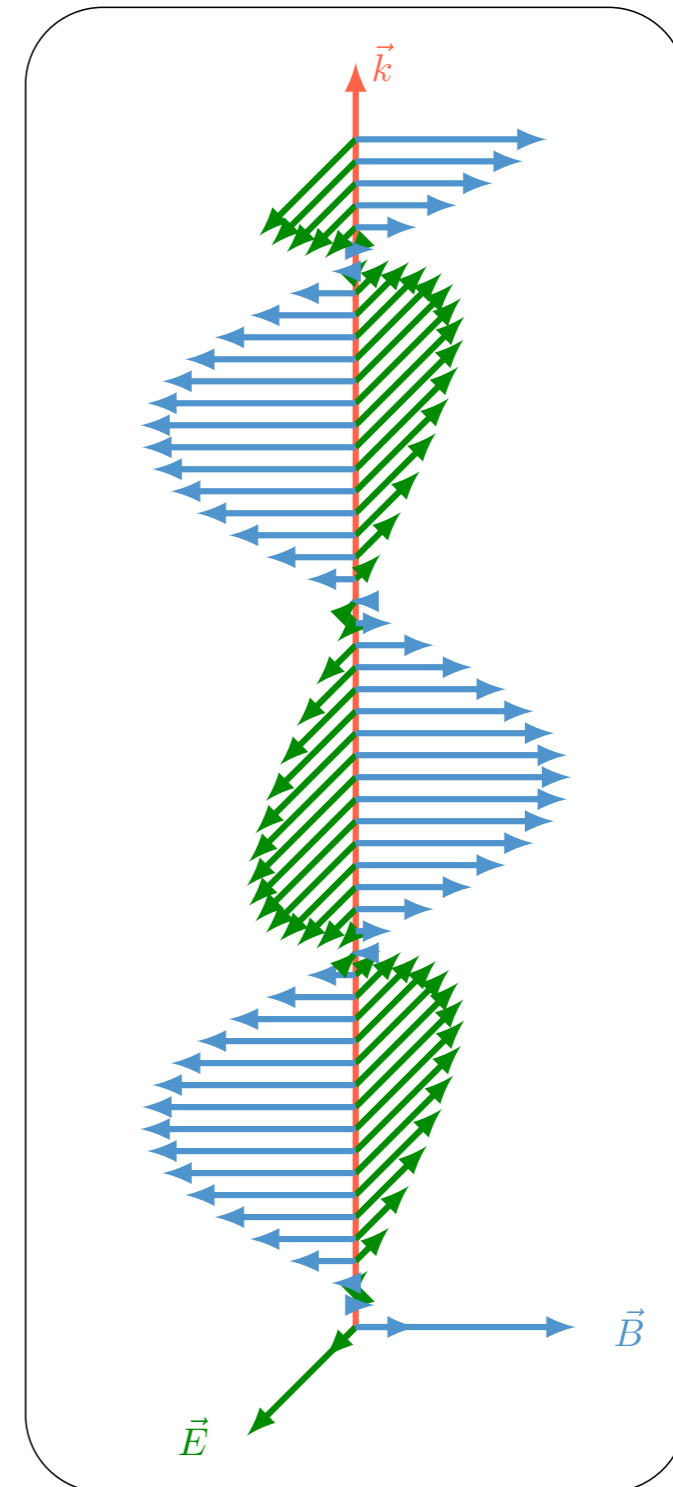


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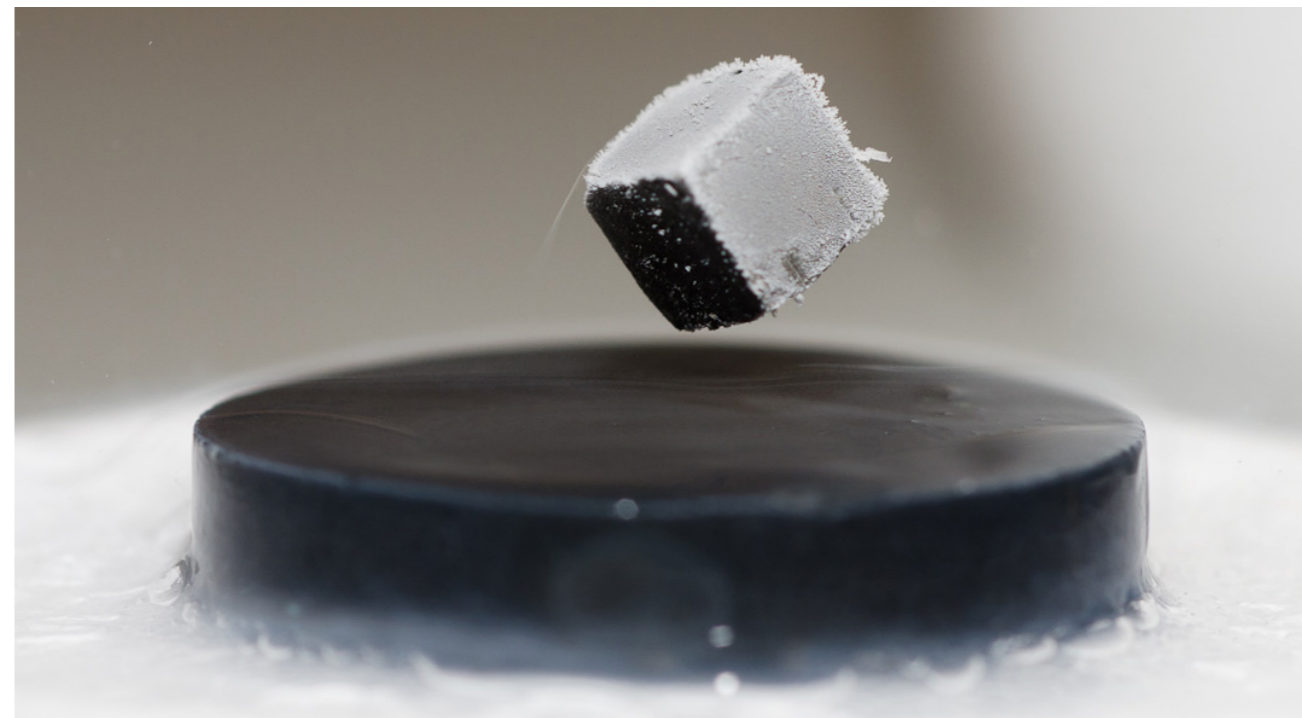
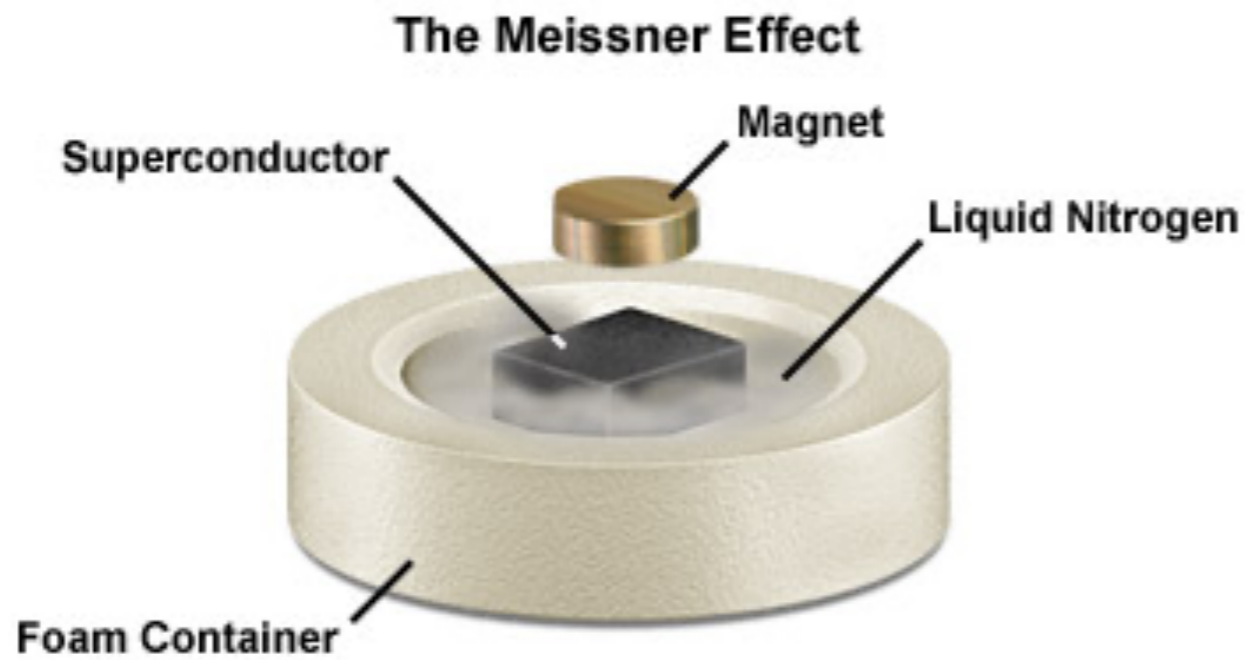
Supercondutividade

Superconducting Elements

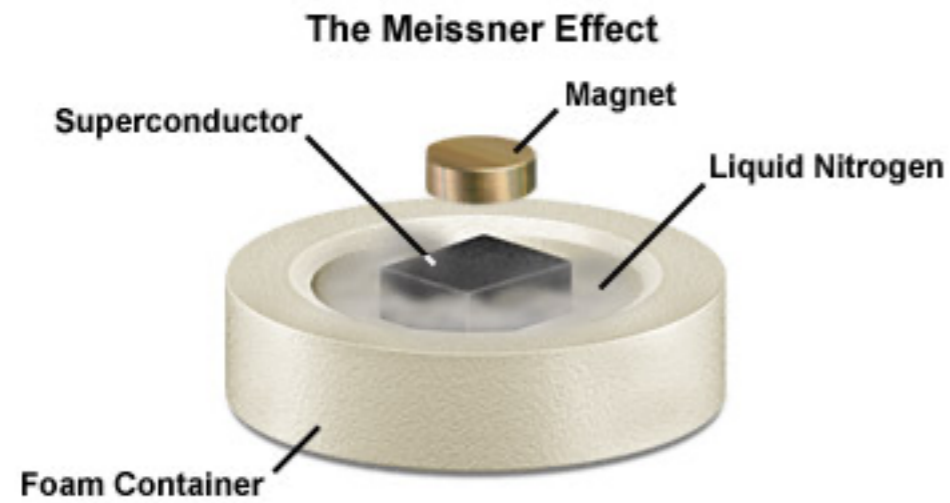
In Bulk at Ambient Pressure
 At High Pressure
 In Modified Form

1	1	H																	2	He										
2	3	Li	4	Be											5	6	7	8	9	10	Ne									
3	11	Na	12	Mg											13	14	15	16	17	18	Ar									
4	19	K	20	21	22	23	24	26	27	28	29	30	31	32	33	34	35	36	Kr											
5	37	Rb	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	Xe										
6	55	Cs	56	57	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	Rn										
7	87	Fr	88	Ra	89	Ac	104	Rf	105	Ha	106	Sg	107	Bh	108	Hs	109	Mt	110	Ds	111	Rg	112	Uub						
		58	59	Pr	60	Nd	61	Pm	62	Sm	63	Eu	64	Gd	65	Tb	66	Dy	67	Ho	68	Er	69	Tm	70	Yb	71	Lu		
		90	91	92	93	94	95	96	97	98	99	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118

Supercondutividade

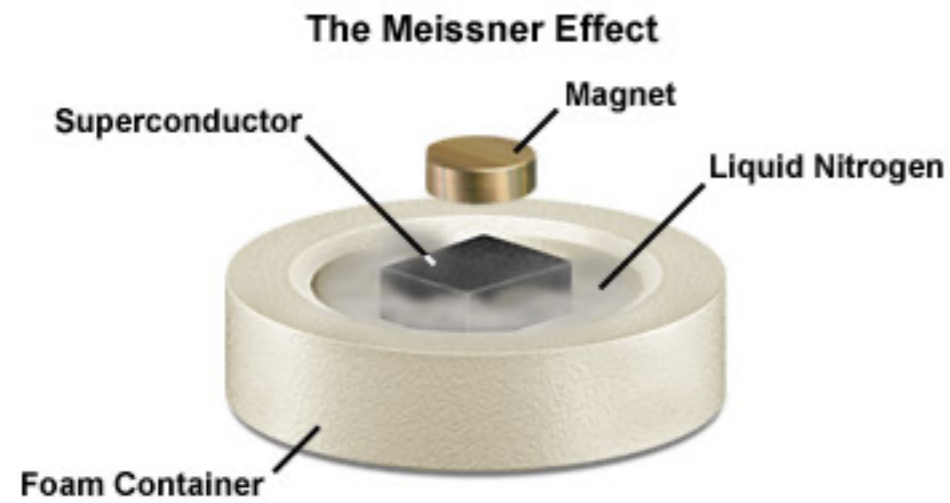


Supercondutividade



$$\vec{j} = \sigma \vec{E}$$

Supercondutividade



$$\vec{j} = \sigma \vec{E}$$

$$\vec{j} = \alpha \vec{A}$$