Eletromagnetismo Avançado

30 de outubro

Relatividade restrita

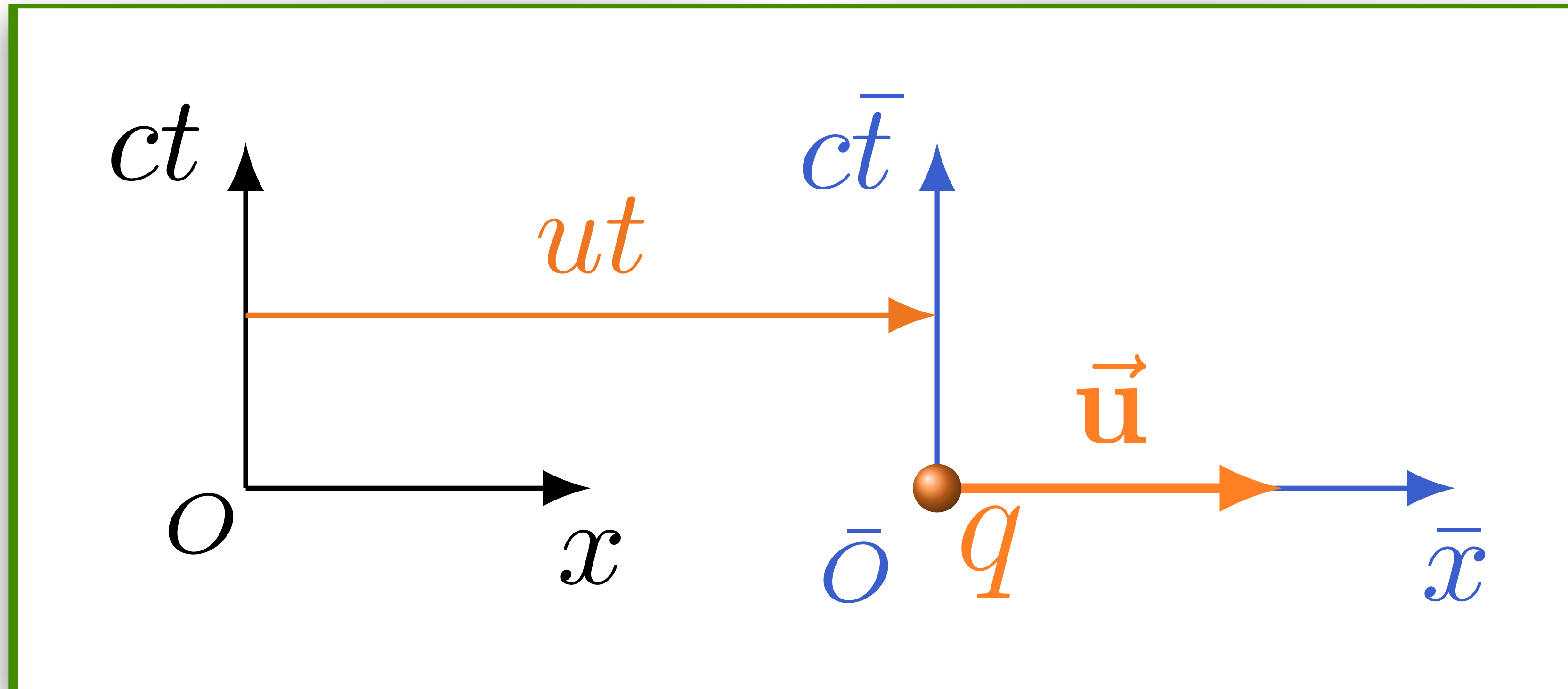
Potenciais e relatividade

$$A^{\mu} = \frac{1}{\sqrt{1 - \frac{u^2}{c^2}}} \begin{bmatrix} V/c \\ A^1 \\ A^2 \\ A^3 \end{bmatrix}$$

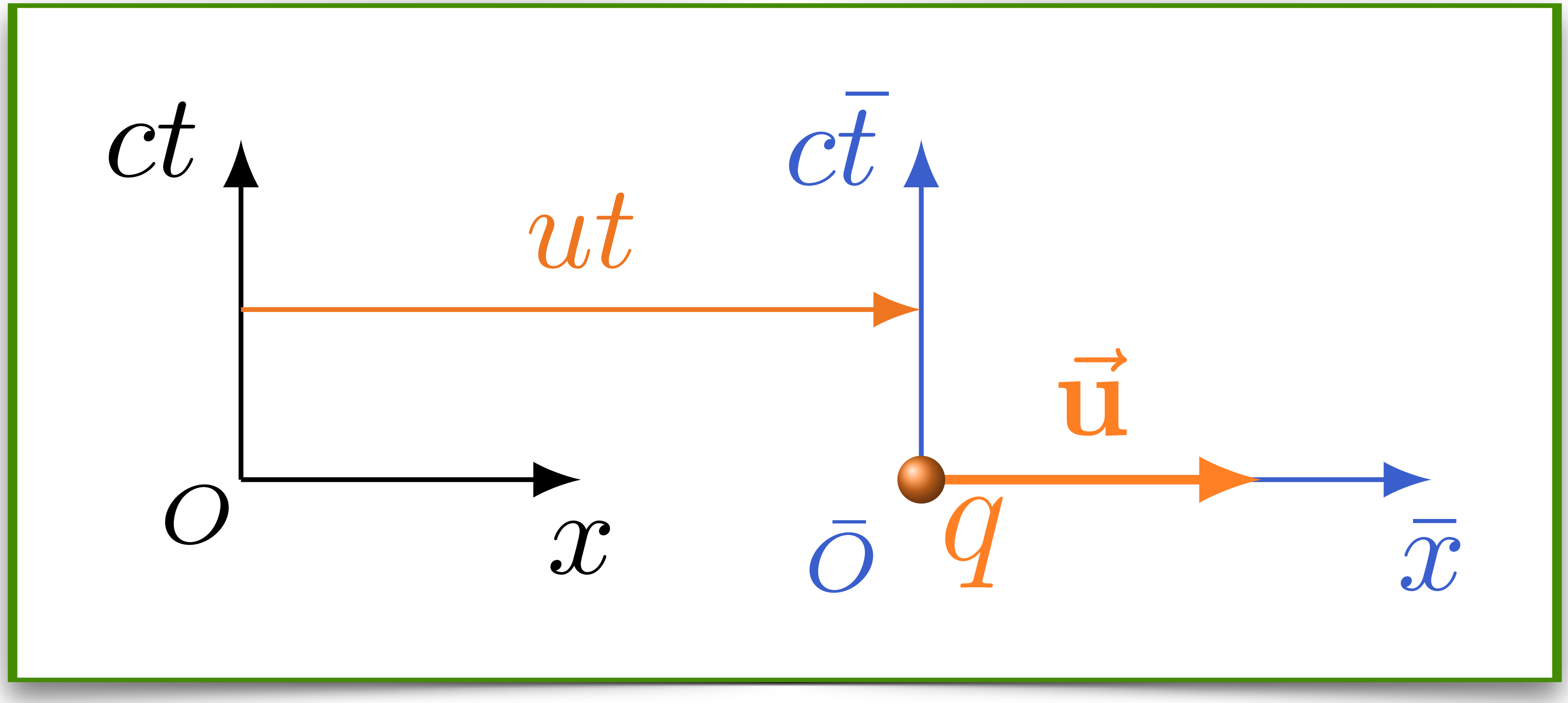
$$A^{\mu} A_{\mu} = -V^2/c^2$$

Potenciais e relatividade

$$A^\mu = \frac{1}{\sqrt{1-\frac{u^2}{c^2}}}\begin{bmatrix} V/c \\ A^1 \\ A^2 \\ A^3 \end{bmatrix}$$



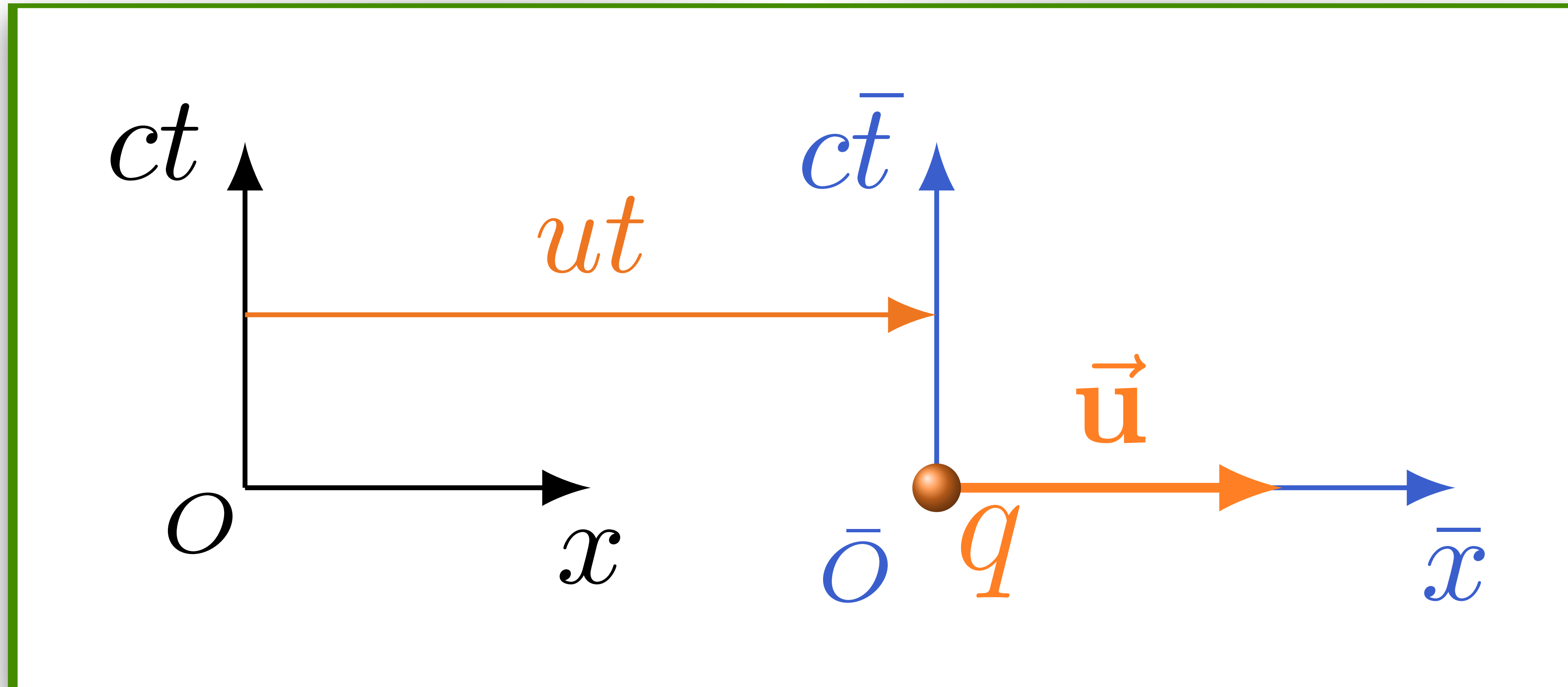
Potenciais e relatividade



<u>LABORATÓRIO</u>

Carga parada $\Rightarrow \begin{cases} \bar{V} &= \dfrac{q}{4\pi\epsilon_0 r} \\ \bar{A} &= 0 \end{cases}$

Potenciais e relatividade



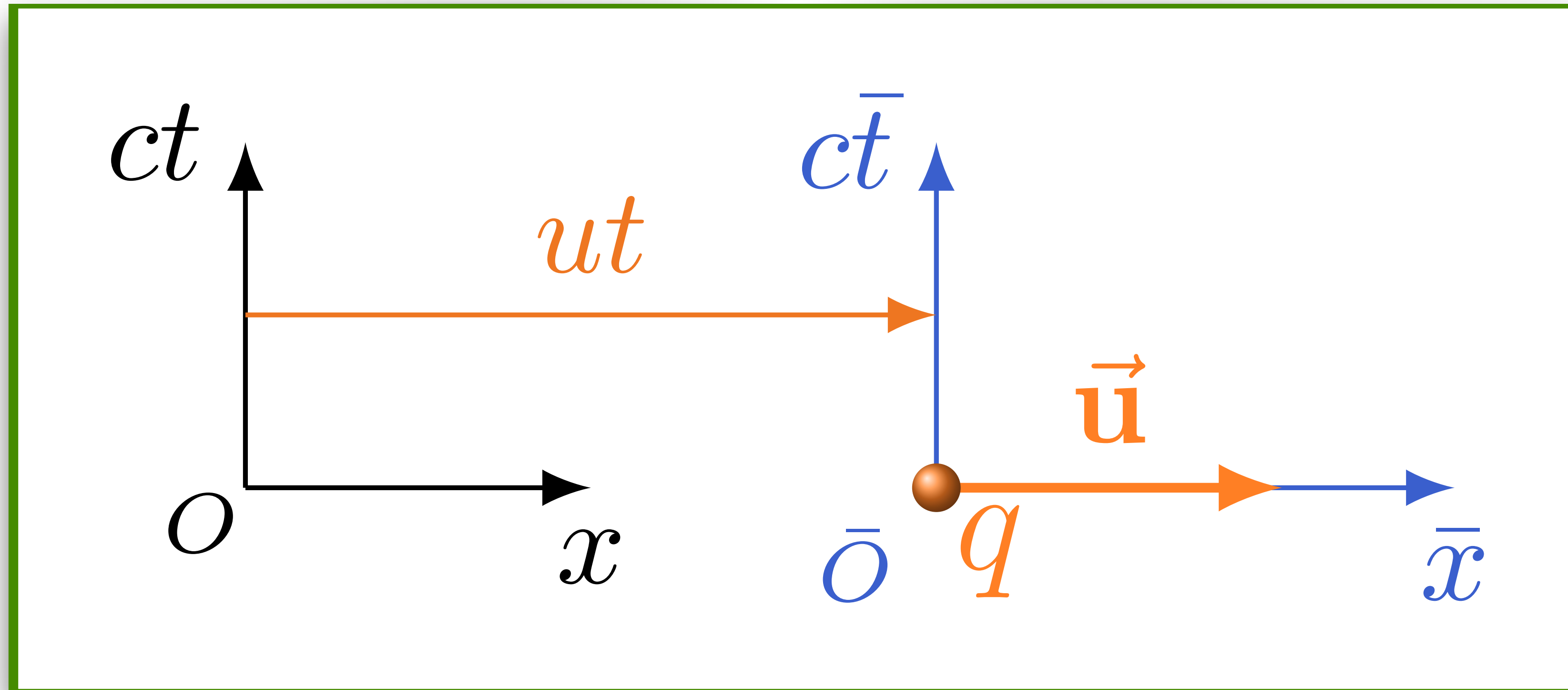
MÓVEL

Carga com velocidade $\vec{u} \Rightarrow A^{\mu} = \dfrac{\mathscr{V}/c^2}{\sqrt{1-\dfrac{u^2}{c^2}}}\begin{bmatrix} c \\ u^1 \\ u^2 \\ u^3 \end{bmatrix}$

$\mathscr{V} = ?$

Potenciais e relatividade

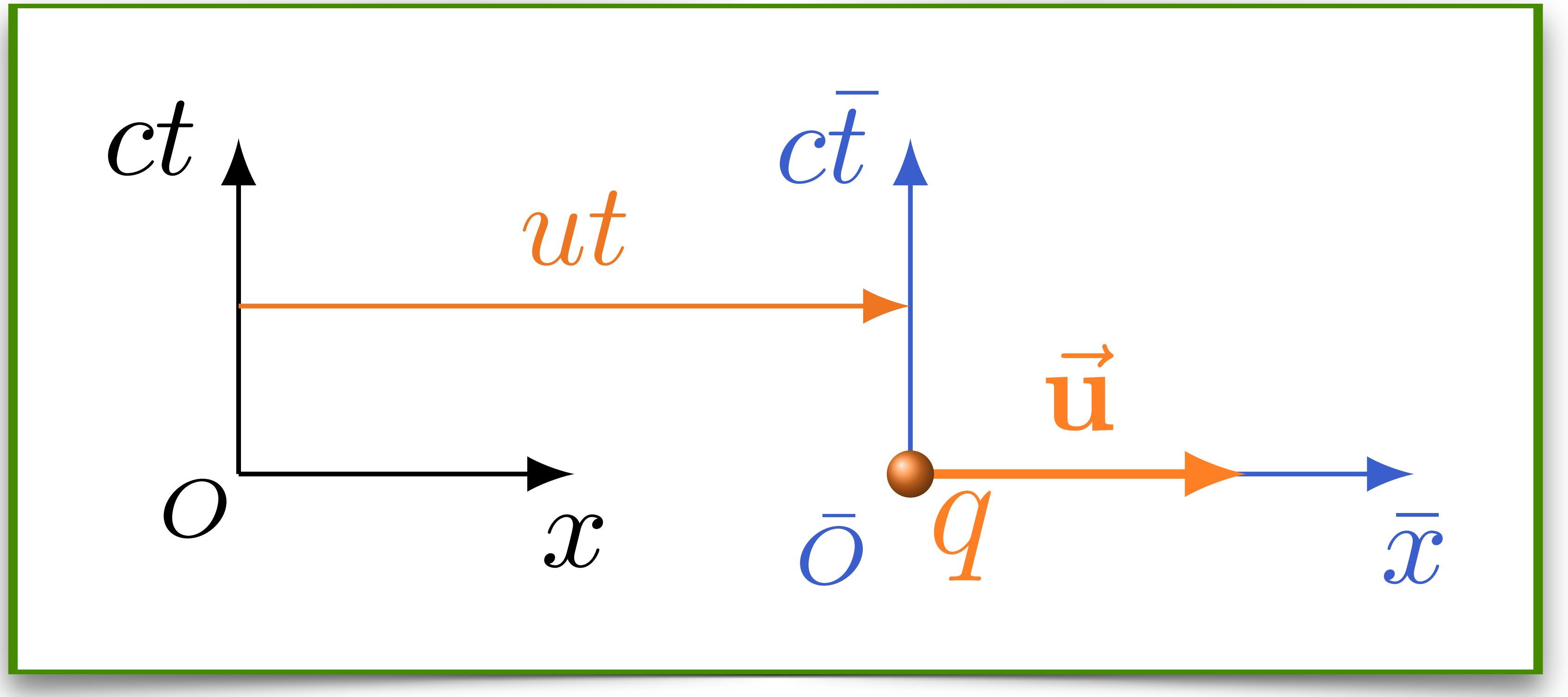
$$A^\mu = \frac{\mathcal{V}/c^2}{\sqrt{1-\frac{u^2}{c^2}}}\begin{bmatrix} c \\ u^1 \\ u^2 \\ u^3 \end{bmatrix}$$



$$\mathcal{V} = \begin{cases} \text{Invariante} \\ \dfrac{q}{4\pi\epsilon_0 r} \quad \text{(MÓVEL)} \end{cases}$$

Potenciais e relatividade

$$A^\mu = \frac{\mathcal{V}/c^2}{\sqrt{1-\frac{u^2}{c^2}}}\begin{bmatrix} c \\ u^1 \\ u^2 \\ u^3 \end{bmatrix}$$

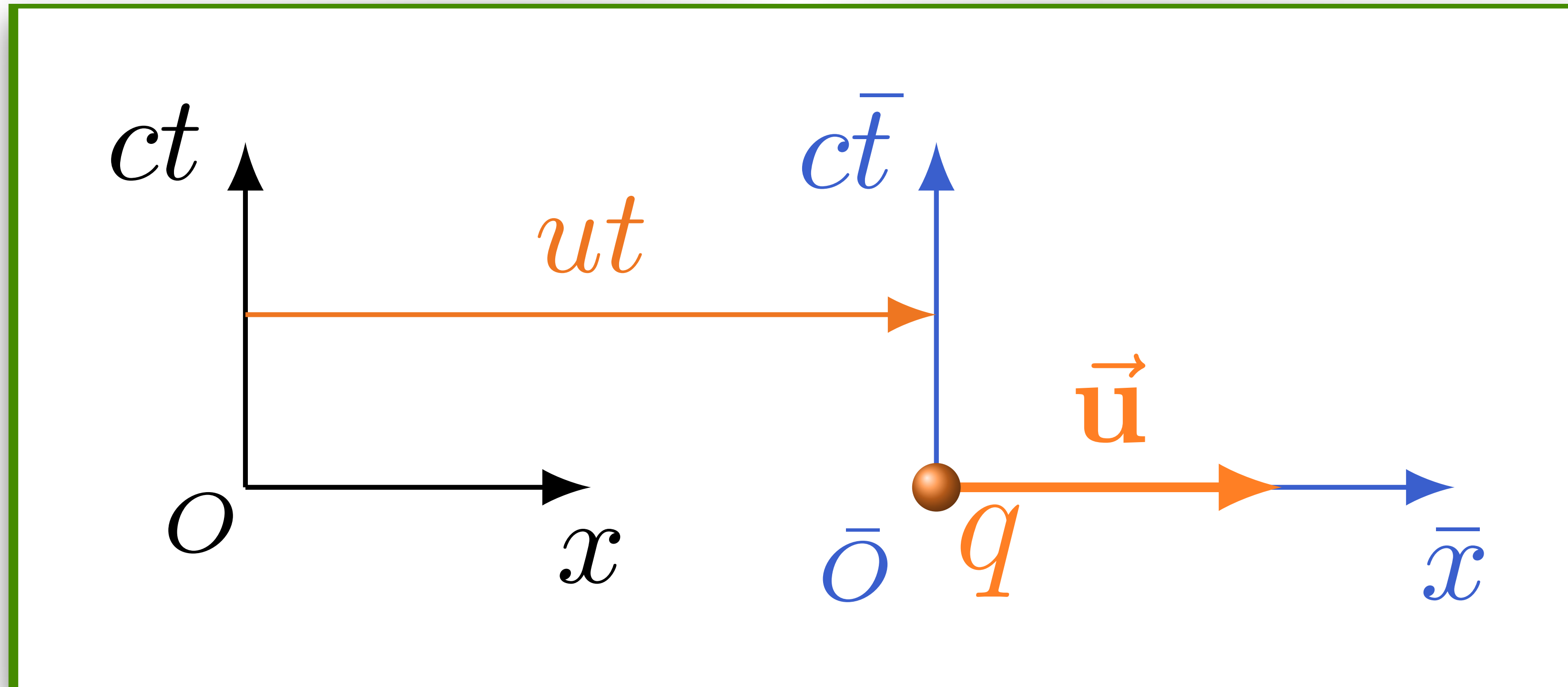


$$\mathcal{V} = \begin{cases} \text{Invariante} \\ \dfrac{q}{4\pi\epsilon_0 r} \quad \text{(MÓVEL)} \end{cases}$$

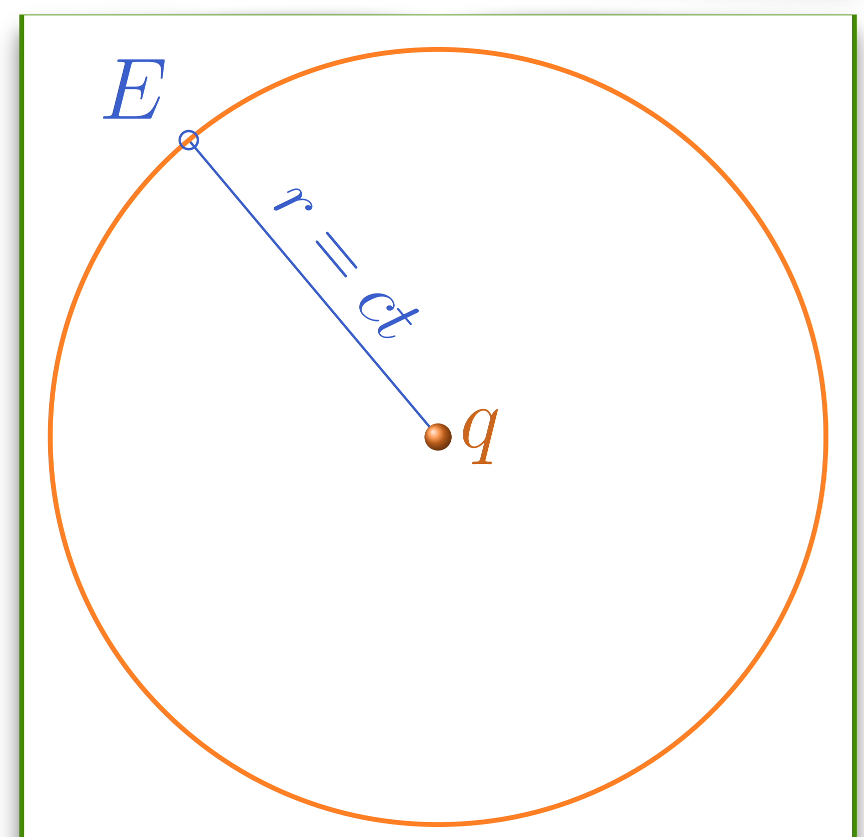
$r \rightarrow$ Invariante ?

Potenciais e relatividade

$$A^\mu = \frac{\mathcal{V}/c^2}{\sqrt{1-\frac{u^2}{c^2}}}\begin{bmatrix} c \\ u^1 \\ u^2 \\ u^3 \end{bmatrix}$$



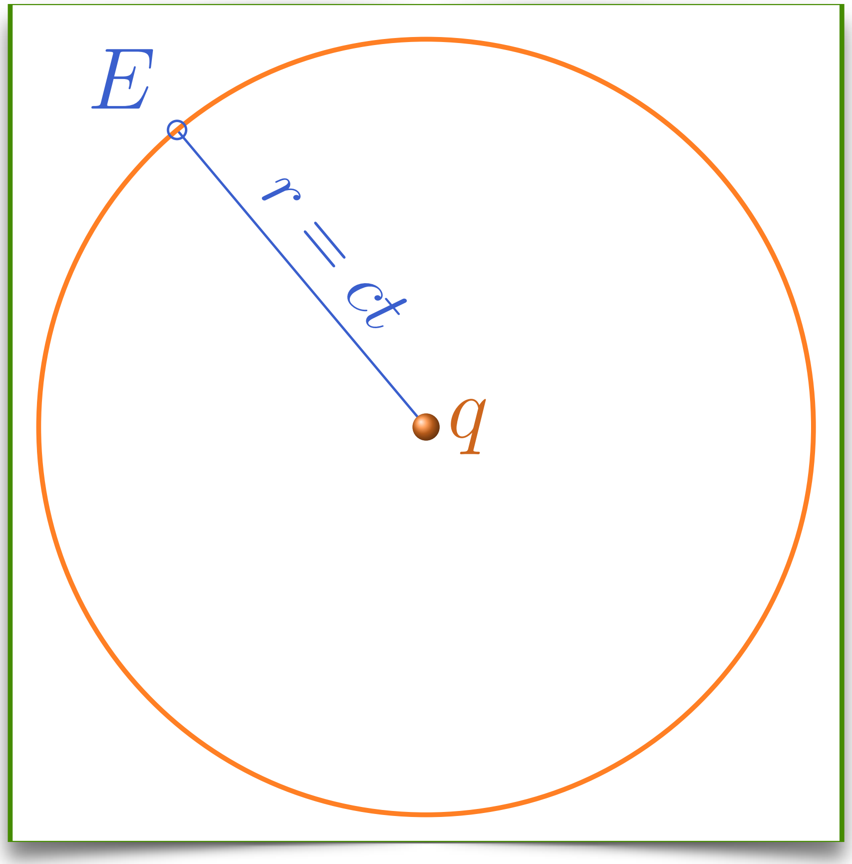
$$\mathcal{V} = \begin{cases} \text{Invariante} \\ \dfrac{q}{4\pi\epsilon_0 r} \quad (\text{MÓVEL}) \end{cases}$$



$r \rightarrow$ Invariante ?

Potenciais e relatividade

$$A^\mu = \frac{\mathcal{V}/c^2}{\sqrt{1-\frac{u^2}{c^2}}}\begin{bmatrix} c \\ u^1 \\ u^2 \\ u^3 \end{bmatrix}$$

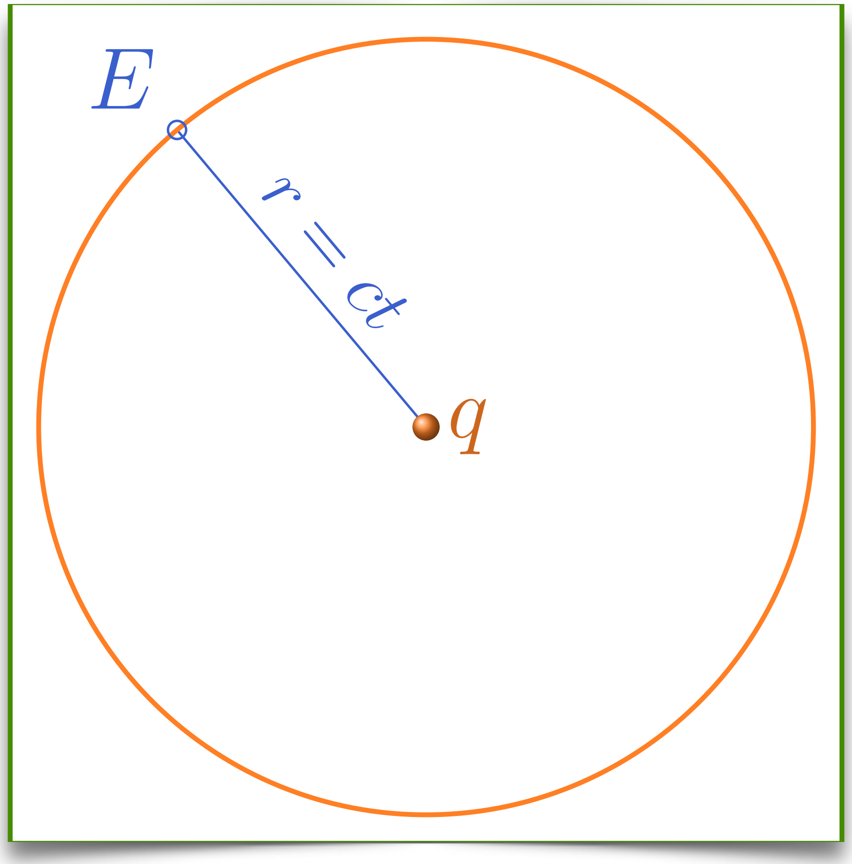


$r \rightarrow$ Invariante

$$x^\mu = \begin{bmatrix} ct \\ x^1 \\ x^2 \\ x^3 \end{bmatrix}$$

Potenciais e relatividade

$$A^\mu = \frac{\mathcal{V}/c^2}{\sqrt{1-\frac{u^2}{c^2}}}\begin{bmatrix} c \\ u^1 \\ u^2 \\ u^3 \end{bmatrix}$$



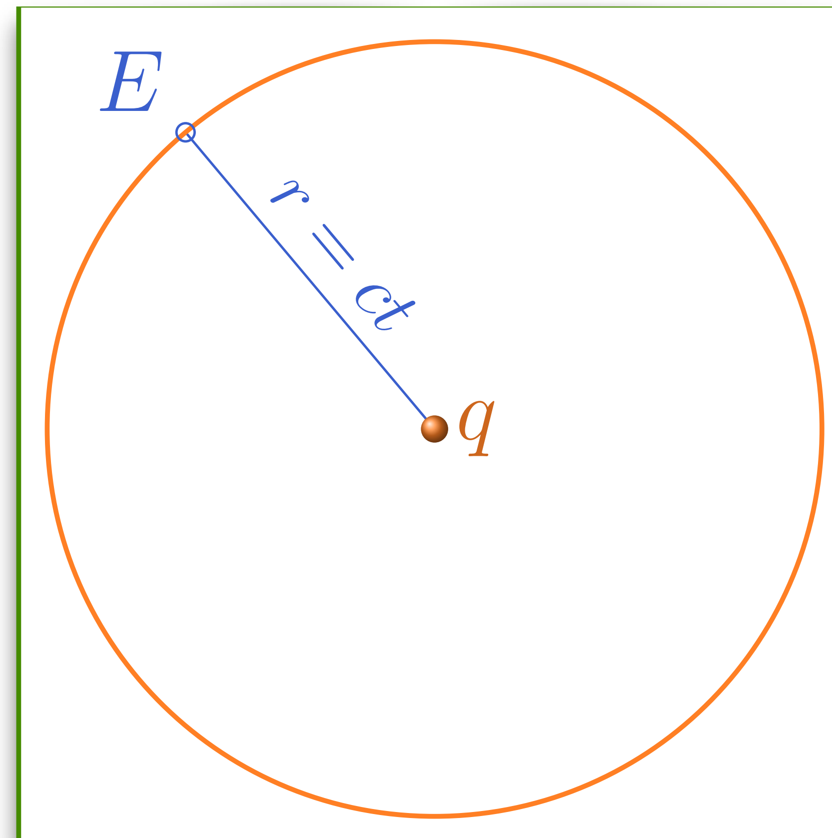
$r \rightarrow$ Invariante

$$x^\mu = \begin{bmatrix} r \\ x^1 \\ x^2 \\ x^3 \end{bmatrix}$$

Potenciais e relatividade

$$A^{\mu} = \frac{\mathcal{V}/c^2}{\sqrt{1 - \frac{u^2}{c^2}}} \begin{bmatrix} c \\ u^1 \\ u^2 \\ u^3 \end{bmatrix}$$

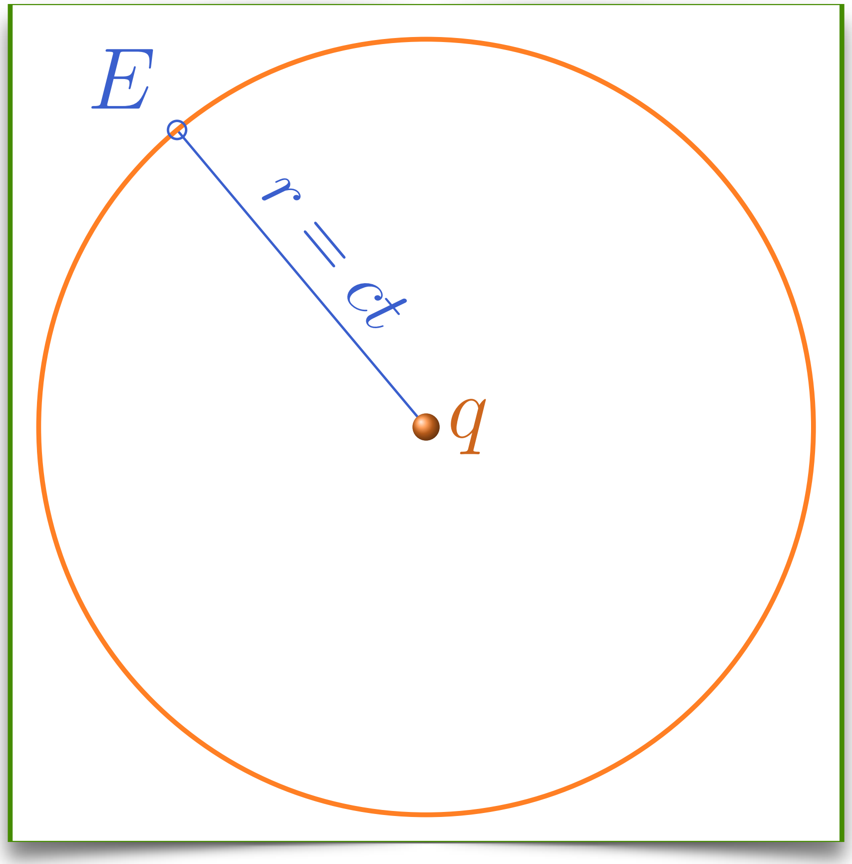
$r \rightarrow \text{Invariante}$



$$x^{\mu} = \begin{bmatrix} r \\ x^1 \\ x^2 \\ x^3 \end{bmatrix} \Rightarrow \quad x^{\mu} x_{\mu} = 0$$

Potenciais e relatividade

$$A^\mu = \frac{\mathcal{V}/c^2}{\sqrt{1-\frac{u^2}{c^2}}}\begin{bmatrix} c \\ u^1 \\ u^2 \\ u^3 \end{bmatrix}$$

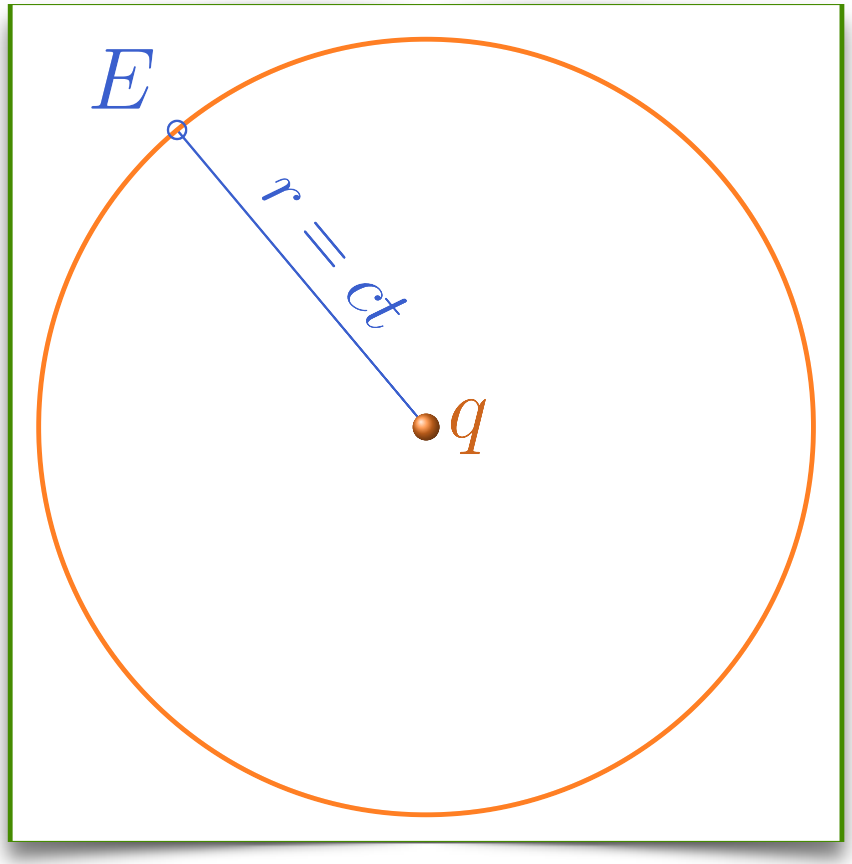


$r \rightarrow$ Invariante

$$x^\mu = \begin{bmatrix} r \\ x^1 \\ x^2 \\ x^3 \end{bmatrix} \quad \eta_\mu = \frac{1}{\sqrt{1-\frac{u^2}{c^2}}}\begin{bmatrix} -c & u_1 & u_2 & u_3 \end{bmatrix}$$

Potenciais e relatividade

$$A^\mu = \frac{\mathcal{V}/c^2}{\sqrt{1-\frac{u^2}{c^2}}}\begin{bmatrix} c \\ u^1 \\ u^2 \\ u^3 \end{bmatrix}$$

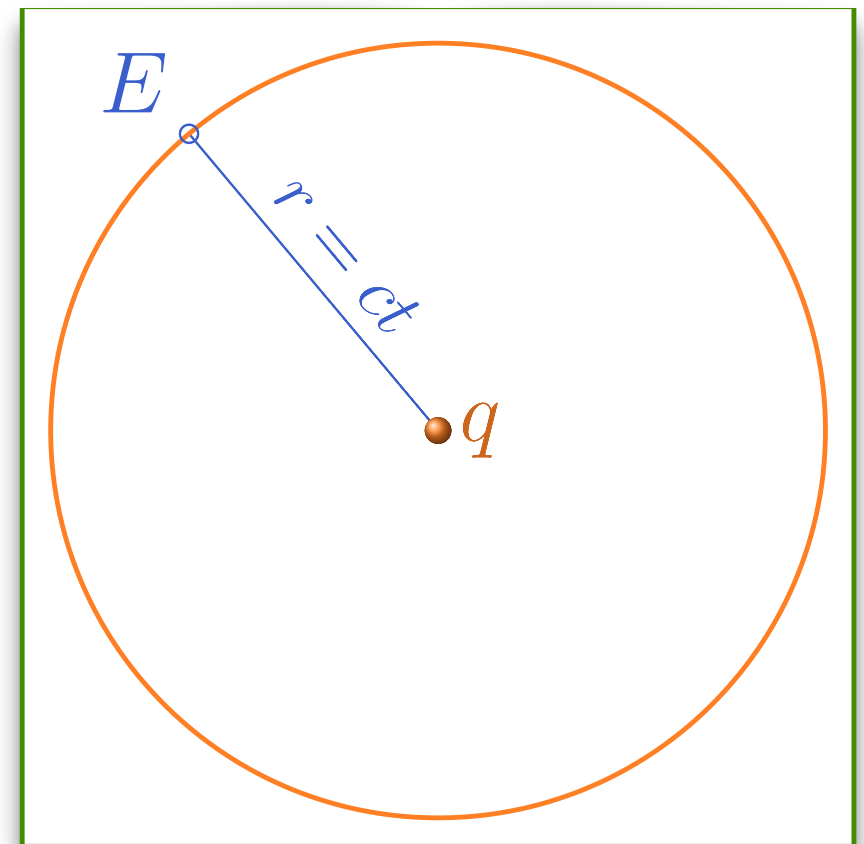


$$r \rightarrow \text{Invariante}$$

$$\eta_\mu x^\mu = \frac{-cr + \vec{\mathbf{u}}\cdot\vec{\mathbf{r}}}{\sqrt{1-\frac{u^2}{c^2}}} \quad \Rightarrow \quad -\frac{\eta_\mu x^\mu}{c} = \frac{r - \frac{\vec{\mathbf{u}}}{c}\cdot\vec{\mathbf{r}}}{\sqrt{1-\frac{u^2}{c^2}}}$$

Potenciais e relatividade

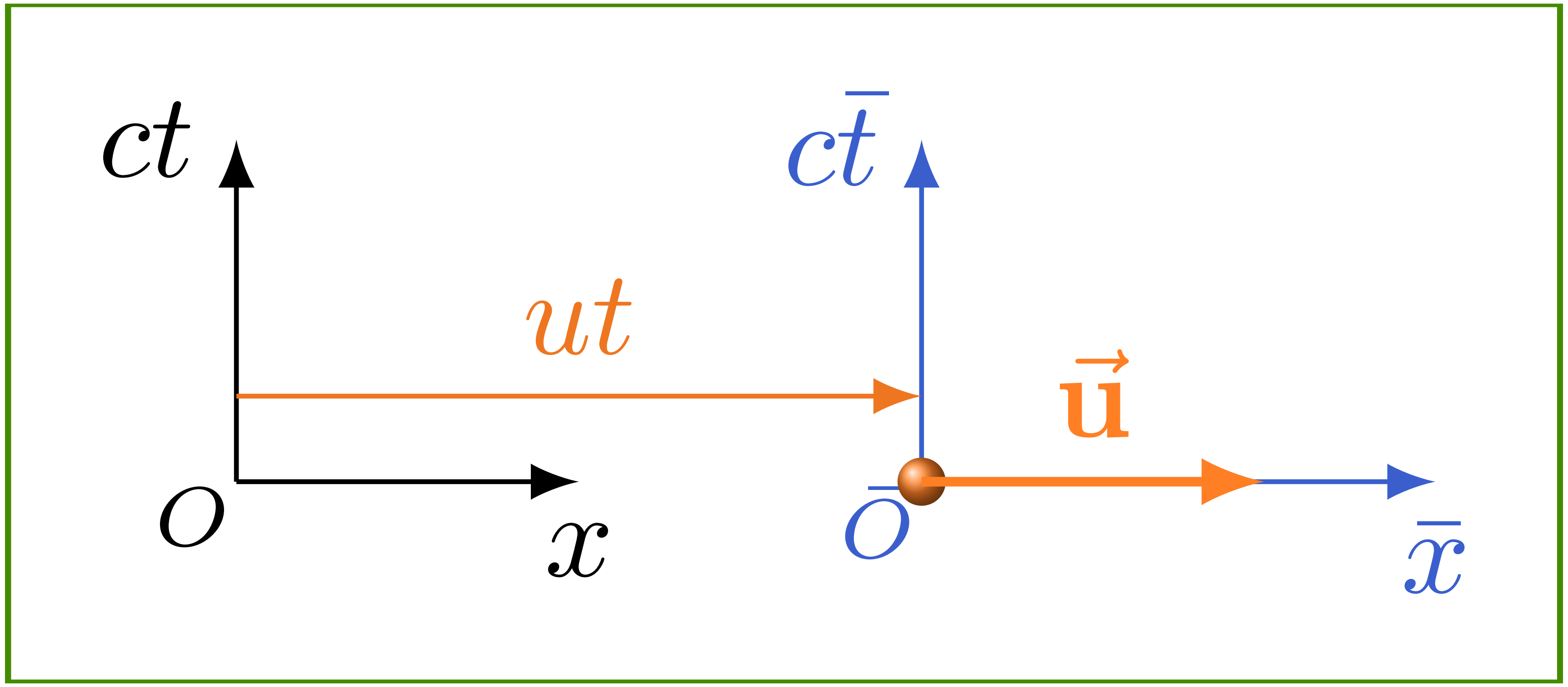
$$A^\mu = \frac{\mathcal{V}/c^2}{\sqrt{1-\dfrac{u^2}{c^2}}} \begin{bmatrix} c \\ u^1 \\ u^2 \\ u^3 \end{bmatrix}$$



$r \rightarrow$ Invariante

$$r \rightarrow \frac{r - \dfrac{\vec{\mathbf{u}}}{c}\cdot\vec{\mathbf{r}}}{\sqrt{1-\dfrac{u^2}{c^2}}} \quad \Rightarrow \quad \frac{q}{4\pi\epsilon_0 r}\frac{1}{\sqrt{1-\dfrac{u^2}{c^2}}} \rightarrow \frac{q}{4\pi\epsilon_0\left(r - \dfrac{\vec{\mathbf{u}}}{c}\cdot\vec{\mathbf{r}}\right)}$$

Potenciais e relatividade



$$V = \frac{q}{4\pi\epsilon_0\left(r - \frac{\vec{\mathbf{u}}}{c}\cdot\vec{\mathbf{r}}\right)}$$

$$\bar{V} = \frac{q}{4\pi\epsilon_0 r}$$

$$\vec{\mathbf{A}} = \mu_0 \frac{q\vec{\mathbf{u}}}{4\pi\left(r - \frac{\vec{\mathbf{u}}}{c}\cdot\vec{\mathbf{r}}\right)}$$

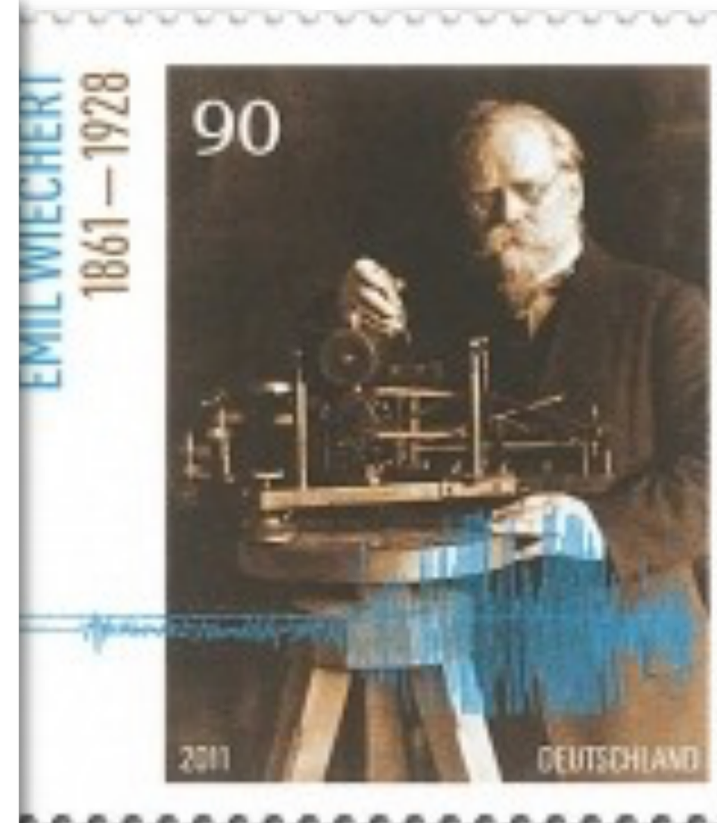
$$\bar{\vec{\mathbf{A}}} = 0$$

Potenciais de Liénard e Wiechert

$$V = \frac{q}{4\pi\epsilon_0 (r - \frac{\vec{\mathbf{u}}}{c} \cdot \vec{\mathbf{r}})}$$

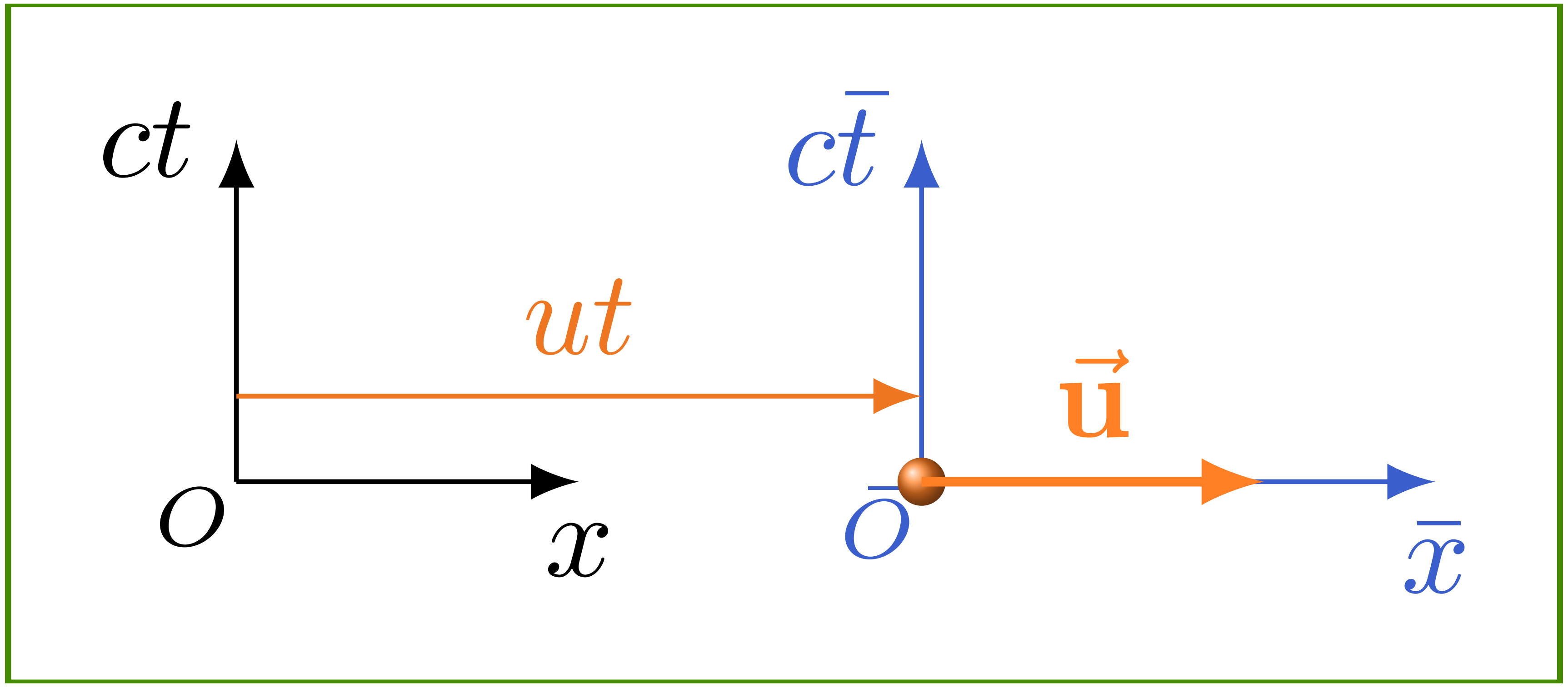
$$\vec{\mathbf{A}} = \mu_0 \frac{q\vec{\mathbf{u}}}{4\pi (r - \frac{\vec{\mathbf{u}}}{c} \cdot \vec{\mathbf{r}})}$$

1898



1900

Potenciais e relatividade



$$\bar{V} = \frac{q}{4\pi\epsilon_0 r}$$

$$\bar{\vec{\mathbf{A}}} = 0$$