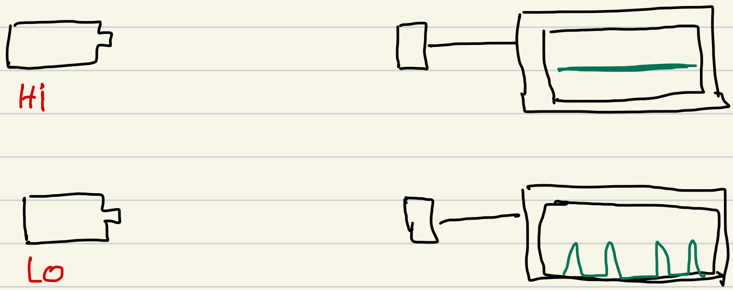
Física Quântica I // Mecânica Quântica

2020-2021

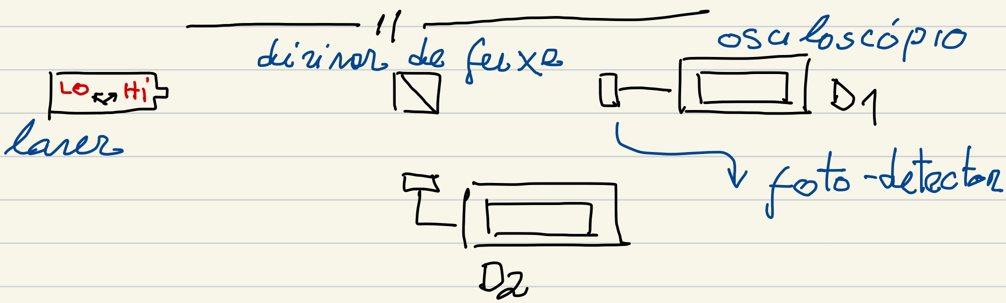
1.) Três experiências com fotões:

EXP 1:

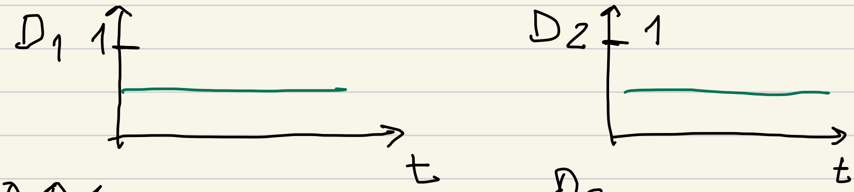


Existe uma quantidade indivisível de luz a que chamamos fotão.

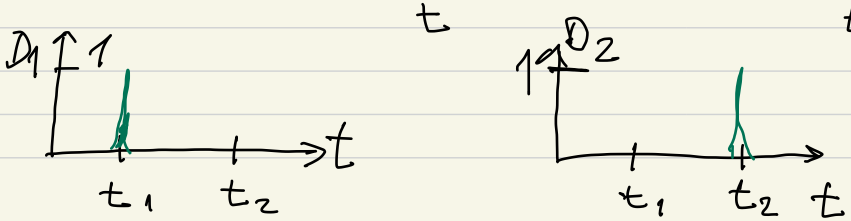
EXP 2:



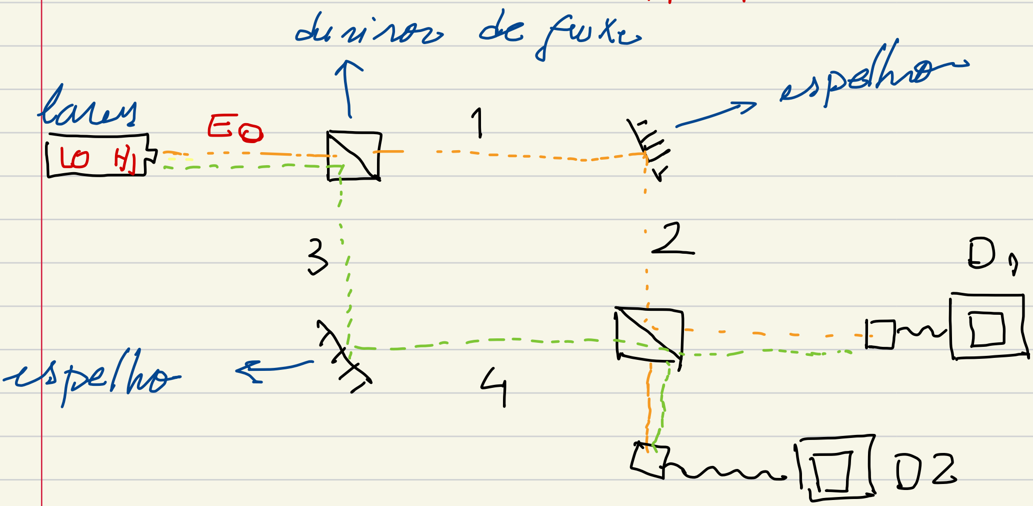
Hi:



Lo:



EXP 3: INTERFERÔMETRO DE MACH-ZEHNDER



Para Hi apenas o D_2 acende.

<u>Interferência clássica</u>:

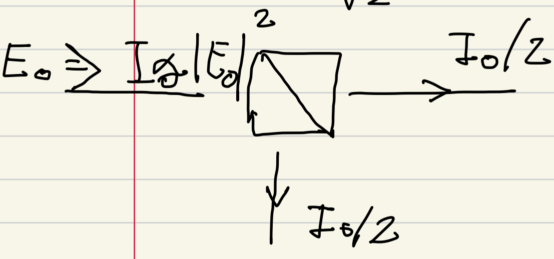
Um detector mede intensidade.

$$I \propto |E|^2$$

$$E_{12} : \frac{1}{\sqrt{2}} E_0 \, e^{i\delta_{12}}$$

$\to *$

$$E_{34} : \frac{1}{\sqrt{2}} E_0 \, e^{i\delta_{34}}$$



$*$

$$|E_{12}|^2 = \frac{1}{\sqrt{2}} E_0 e^{i\delta_{12}} \cdot \frac{1}{\sqrt{2}} E_0 e^{-i\delta_{12}} = \frac{E_0^2}{2} = \frac{I_0}{2}$$

Para o detector D1:

$$E_{D1} = \frac{1}{\sqrt{2}}\left(\frac{1}{\sqrt{2}} E_0 e^{i\delta_{12}} \cdot e^{i\delta_{12}^{r}} + \frac{1}{\sqrt{2}} E_0 e^{i\delta_{34}} \cdot e^{i\delta_{34}^{t}} \right)$$

$$E_{D2} = \frac{1}{\sqrt{2}}\left(\frac{1}{\sqrt{2}} E_0 e^{i\delta_{12}} \cdot e^{i\delta_{12}^{t}} \quad \frac{1}{\sqrt{2}} E_0 e^{i\delta_{34}} \cdot e^{i\delta_{34}^{r}} \right)$$

$$I_{D1} \propto |E_{D1}|^2 = E_{D1} \cdot E_{D1}^{*}$$

$$I_{D2} \propto |E_{D2}|^2 = E_{D2} \cdot E_{D2}^{*}$$

$$I_{D1} \propto |E_{D1}|^2 = E_{D1} \cdot E_{D1}^{*}$$

$$\frac{E_0}{2} \cdot \left(e^{i\delta_{12}} \cdot e^{i\delta_{12}^{r}} + e^{i\delta_{34}} e^{i\delta_{34}^{t}} \right) \cdot$$

$$\frac{E_0}{2} \cdot \left(e^{-i\delta_{12}} \cdot e^{-i\delta_{12}^{r}} + e^{-i\delta_{34}} \cdot e^{-i\delta_{34}^{t}} \right)$$

$$= \frac{E_0^2}{4}\left(2 + 2\cos(\delta_{12} + \delta_{12}^{r} - \delta_{34} - \delta_{34}^{t} \right)$$

$$I_{D_1} \propto \frac{E_0^2}{2}\left(1 + \cos(\delta_1)\right)$$

$$e^{ix} + e^{-ix} = 2\cos(x)$$

$$\delta_1 = \delta_{12} + \delta_{12}^{r} - \delta_{34} - \delta_{34}^{t} .$$

$$0 \leq \delta_1 \leq 2\pi$$

$$\hookrightarrow \; -1 \leq \cos(\delta_1) \leq 1$$

$$\Downarrow \quad 0 \leq I_{D_1} \leq E_0^2$$

—————— // ——————

$$I_{D_2} = \frac{E_0^2}{2}\left(1 + \cos(\delta_2)\right)$$

$$\boxed{\delta_2 = \delta_{12} + \delta_{12}^{t} - \delta_{34} - \delta_{34}^{r}}$$

$$\delta_1 = \delta_{12} + \delta_{12}^{r} - \delta_{34} - \delta_{34}^{t}$$

A experiência mostrou que só D_2 é que ligava $\Rightarrow \delta_1 = \pi$ e $\delta = 0$

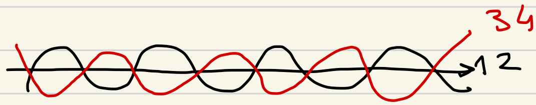
$$\delta_{12} + \delta_{12}^{t} - \delta_{34} - \delta_{34}^{r} = 0$$

$$\delta_{12} + \delta_{12}^{r} - \delta_{34} - \delta_{34}^{t} = \pi$$

$$\boxed{\begin{aligned}\Pi &= \left(\delta_{12}^{R} - \delta_{12}^{t}\right) - \left(\delta_{34}^{t} - \delta_{34}^{R}\right) \\ &= \left(\delta_{12}^{R} + \delta_{34}^{R}\right) - \left(\delta_{12}^{t} + \delta_{34}^{t}\right).\end{aligned}}$$

Estas relações garantem interferência destrutiva:

D_1:



D_2: