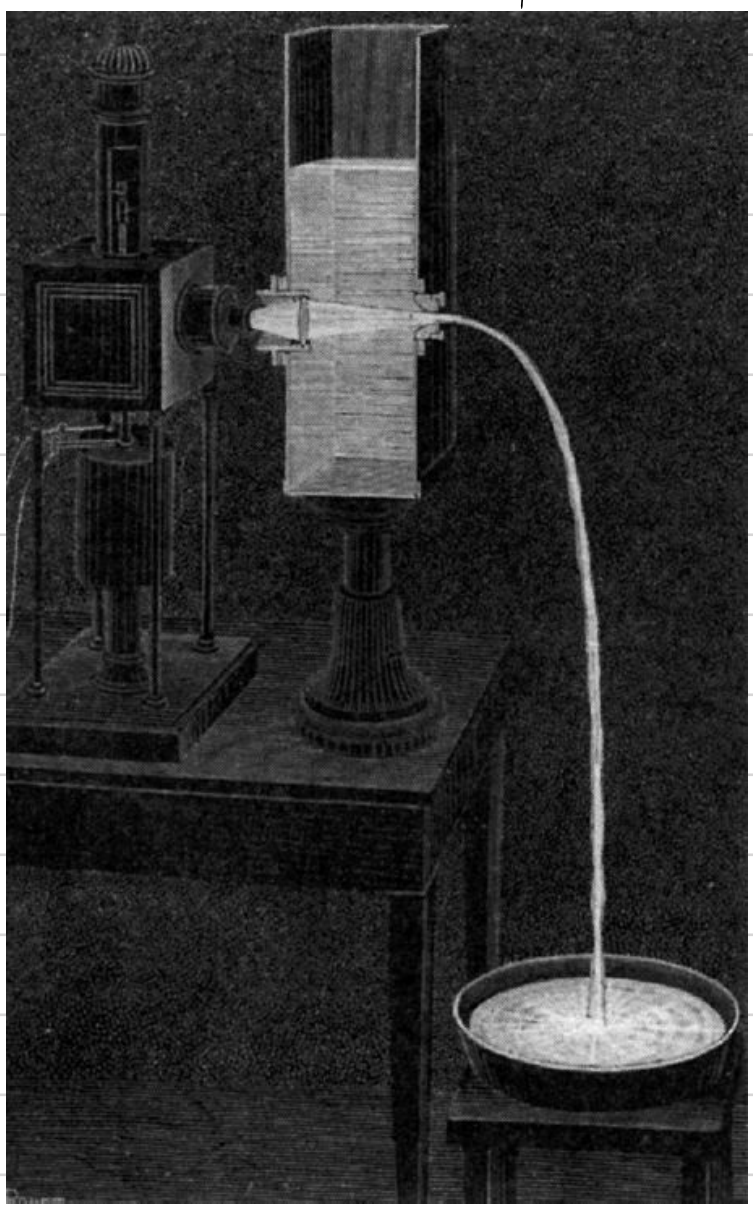
Fibras Ópticas

Tyndal

1870

Colladon



Reflexão Interna total

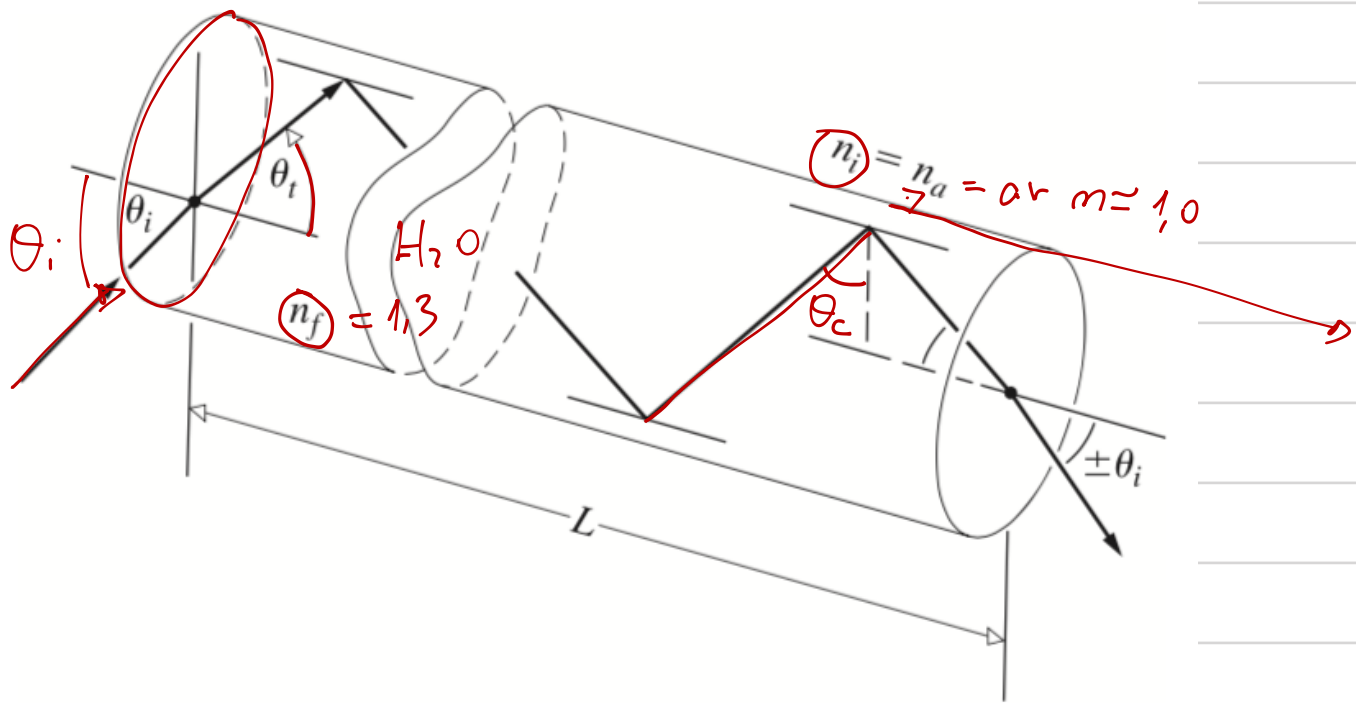


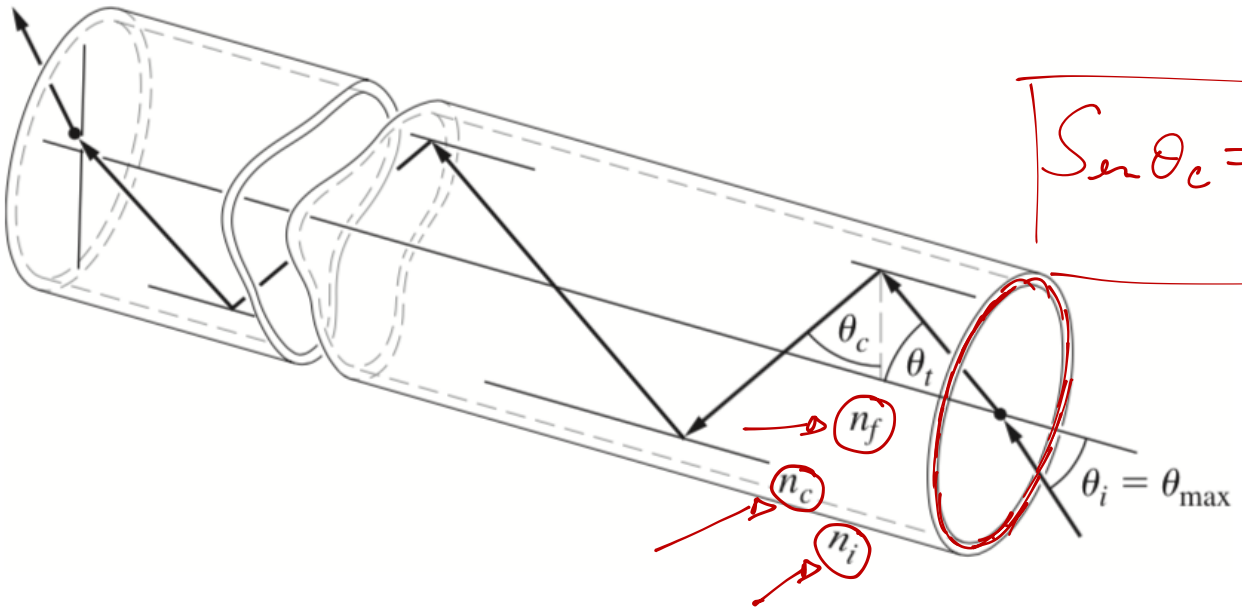
Figure 5.80 Rays reflected within a dielectric cylinder.

Small

$$n_f \operatorname{Sen}\theta_i = n_a \operatorname{Sen}\theta_a$$

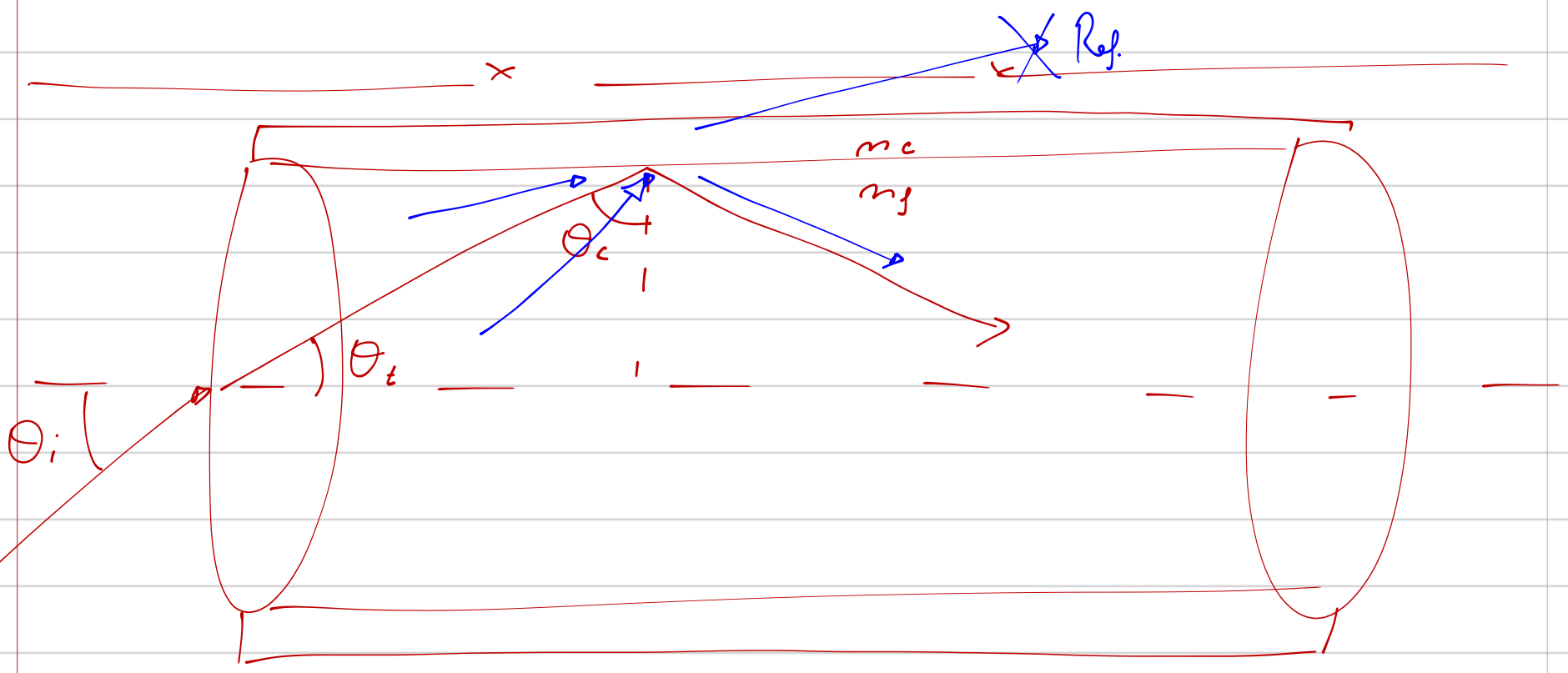
$$n_f \operatorname{Sen}\theta_c = n_a \cdot 1$$

$$\boxed{\operatorname{Sen}\theta_c = \frac{n_a}{n_f}}$$



$$\sin\theta_c = \frac{n_c}{n_f}$$

Figure 5.81 Rays in a clad optical fiber.



$$\sin\theta_c = \frac{n_c}{n_f} \qquad \theta_t + \theta_c = 90$$

$$\sin(90-\theta_t) = \frac{n_c}{n_f} \qquad \sin(a-b) = \sin a\cdot\cos b - \sin b\cdot\cos a$$

$$\cos\theta_t = \frac{n_c}{n_f}$$

$$n_a \sin\theta_i = n_f \sin\theta_t$$

$$\cos^2\theta_t + \sin^2\theta_t = 1$$

$$\sin\theta_t = \sqrt{1-\cos^2\theta_t}$$

$$n_a \sin\theta_i = n_f\sqrt{1-\cos^2\theta_t} = n_f\sqrt{1-\left(\frac{n_c}{n_f}\right)^2}$$

$$\sin^2\theta_i = \frac{n_f^2}{n_a^2}\left(1-\left(\frac{n_c}{n_f}\right)^2\right) = \frac{n_f^2}{n_a^2} - \left(\frac{n_f n_c}{n_f n_a}\right)^2$$

$$\sin^2\theta_i = \frac{1}{n_a^2}\left(n_f^2 - n_c^2\right)$$

→ θ_i máximo aceito p/ q ocorra a reflexão interna total

$$n_a \sin\theta_{i\,MAX} = \sqrt{n_f^2 - n_c^2}$$

→ abertura numérica da fibra

$$NA = \sqrt{n_f^2 - n_c^2}$$

Atenuação da luz na fibra

$$A = -10\log\left(\frac{P_0}{P_i}\right) = -10\log\left(\frac{10}{100}\right) = 10\ dB$$

→ atenuação $\alpha \cdot L$

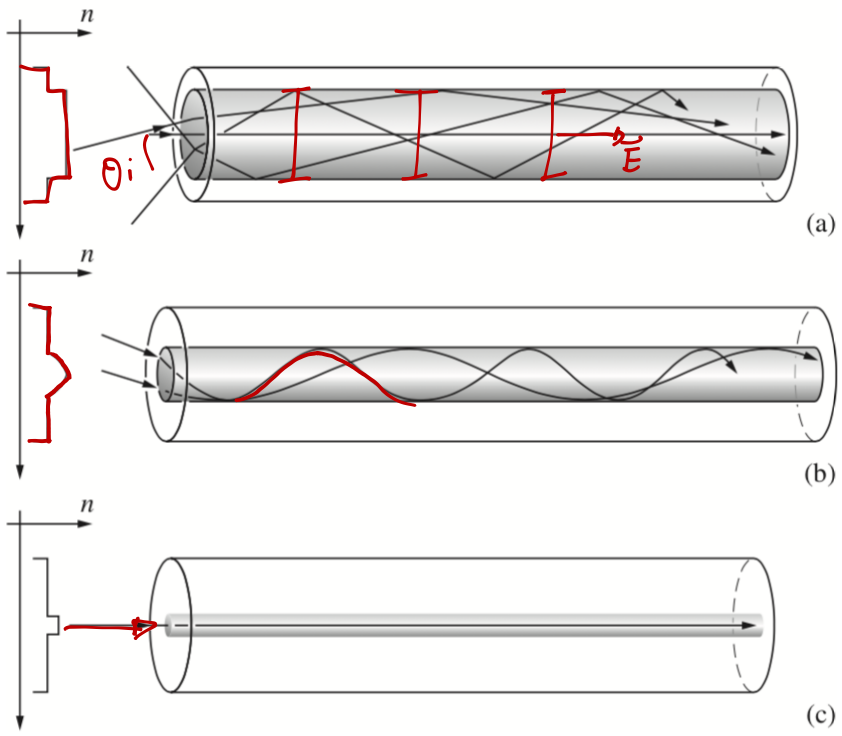
$$[\alpha] = [dB/km]$$

$$\alpha L = -10\log\left(\frac{P_0}{P_i}\right)$$

$$10^{-\frac{\alpha L}{10}} = \frac{P_0}{P_i}$$

$$P_0 = P_i\, 10^{-\frac{\alpha L}{10}}$$

Modos da Fibra

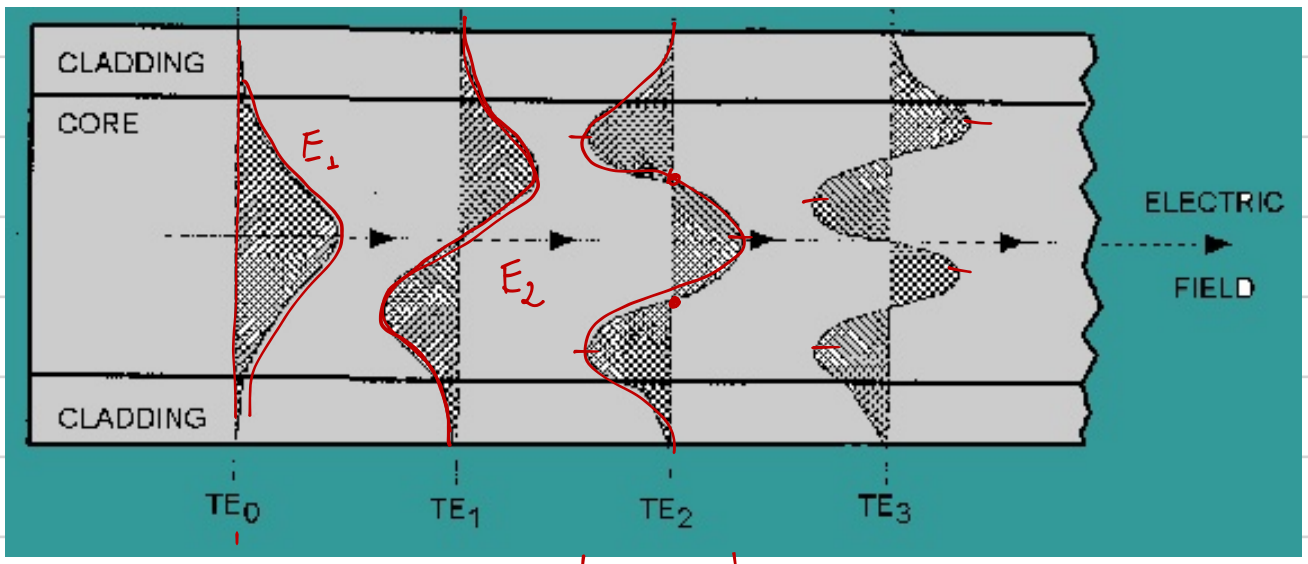


1

2

3

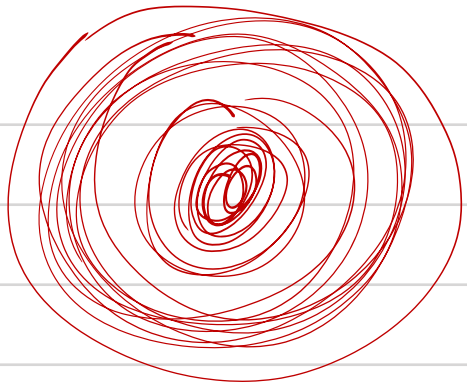
Figure 5.82 The three major fiberoptic configurations and their index profiles. (*a*) Multimode stepped-index fiber. (*b*) Multimode graded-index fiber. (*c*) Single-mode stepped-index fiber.

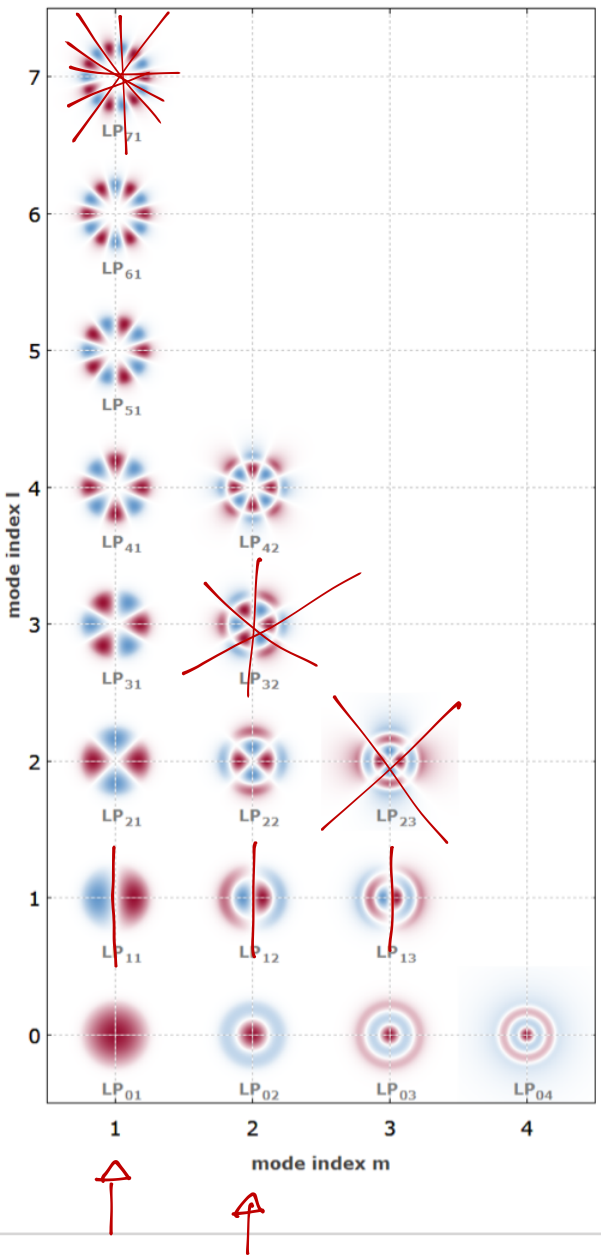


Fibra multimodo

$I \propto E^2$

I

multi-mode fibre ⇒  → gaussiano



Diferentes modos de propagação nas fibras ópticas

Dispersão na fibra óptica

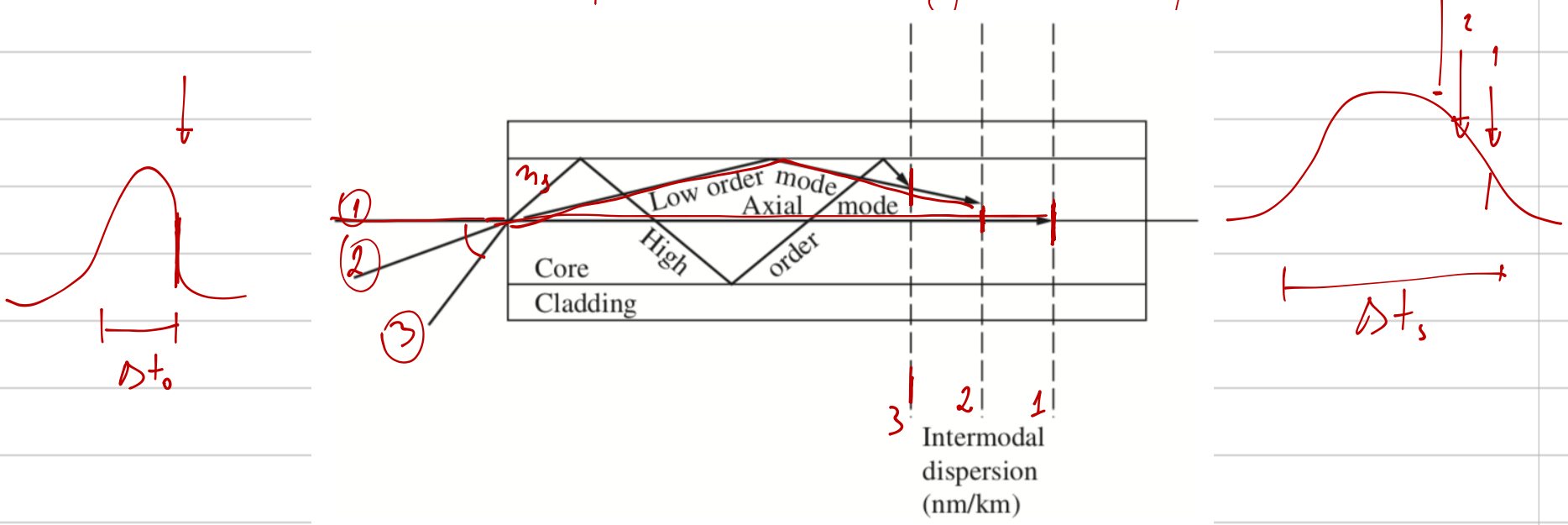
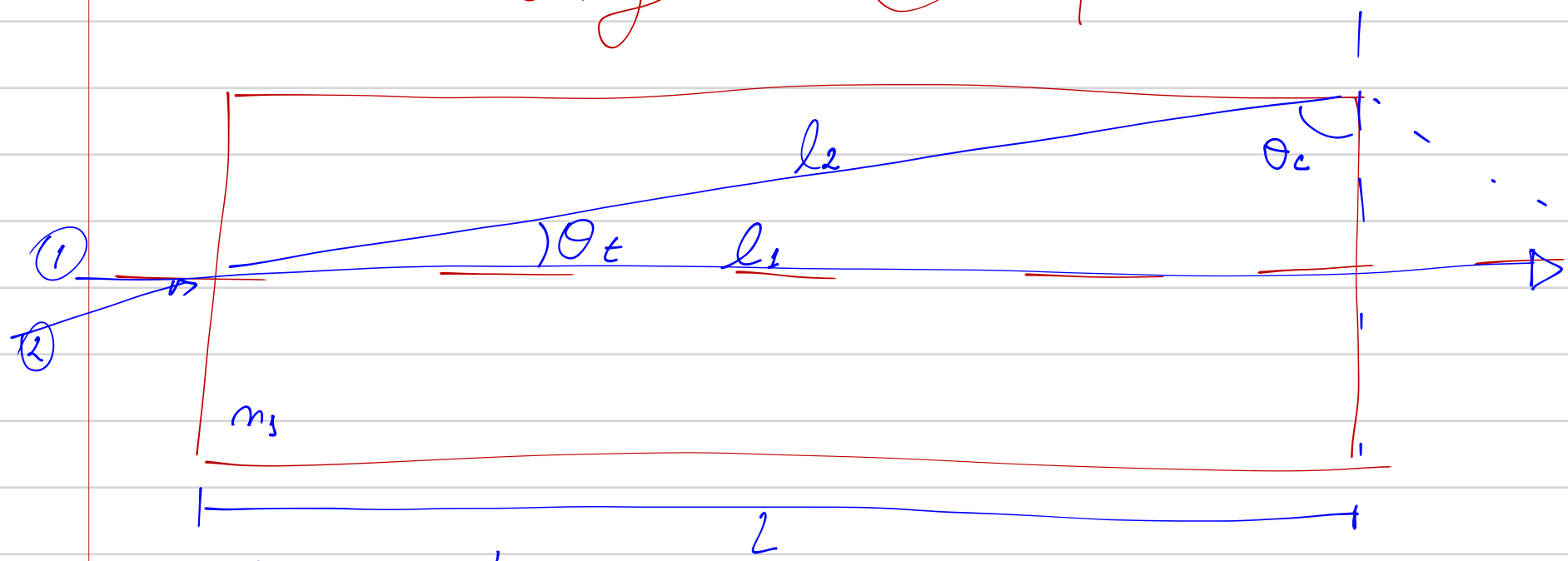


Figure 5.83 Intermodal dispersion in a stepped-index multimode fiber.

Origem da Dispersão



$l_1 \rightarrow t_{mínimo}$

$l_1 \rightarrow t_{máximo}$

$$v_f = \frac{\Delta x}{\Delta t}$$

$$v_f = \frac{c}{n_f}$$

① $$t_1 = \frac{L}{v_f} = \frac{L}{c/n_f}$$

$$\boxed{t_1 = \frac{n_f \cdot L}{c}} \rightarrow Min$$

$$\cos\theta_t = \frac{L}{l_2}$$

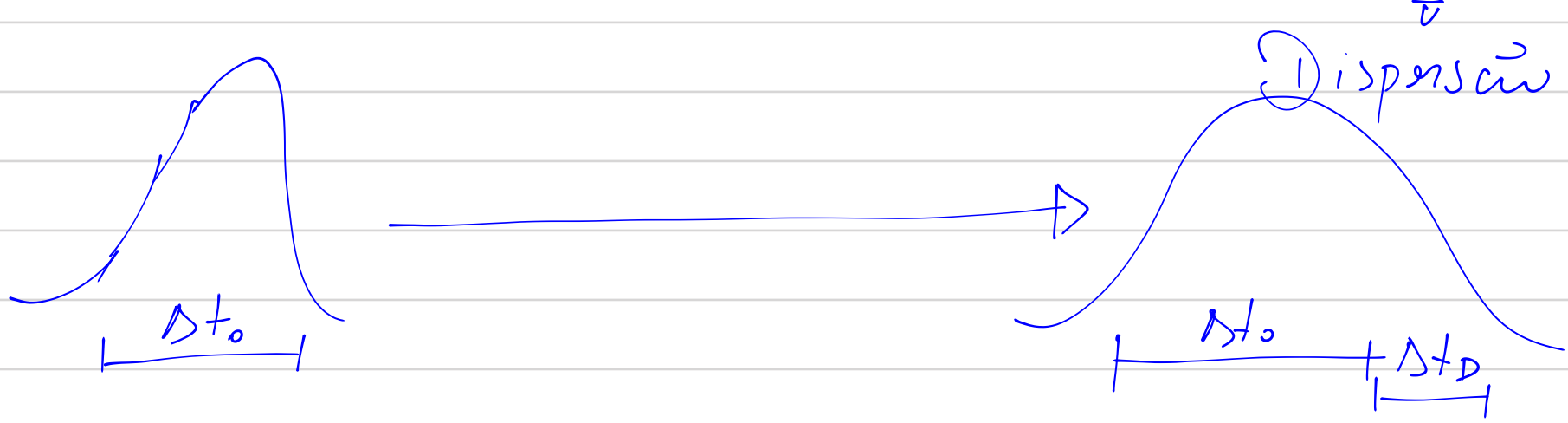
② $$t_2 = \frac{l_2}{v_f} = \frac{L}{\cos\theta_t} \frac{n_f}{c}$$

$$\cos\theta_t = \left(\frac{n_c}{n_f}\right)$$

$$\boxed{t_2 = \frac{L n_f^2}{n_c\, c}} \rightarrow MAX$$

$\Delta t \rightarrow$ diferença de tempo entre os raios

$$= \frac{L n_f^2}{n_c \cdot c} - \frac{n_f L}{c} = \boxed{\frac{L}{c} n_f \left(\frac{n_f}{n_c} - 1\right) = \Delta t_D}$$



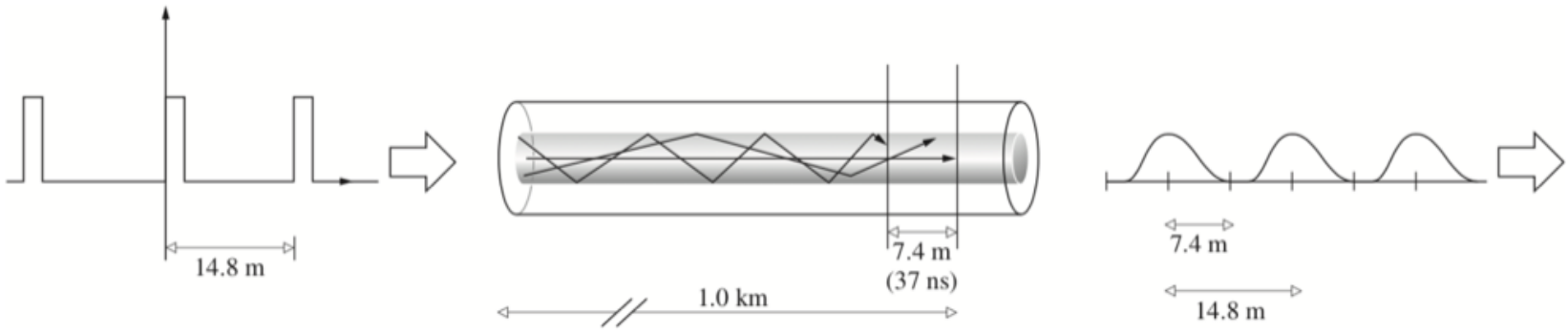


Figure 5.85 The spreading of an input signal due to intermodal dispersion.

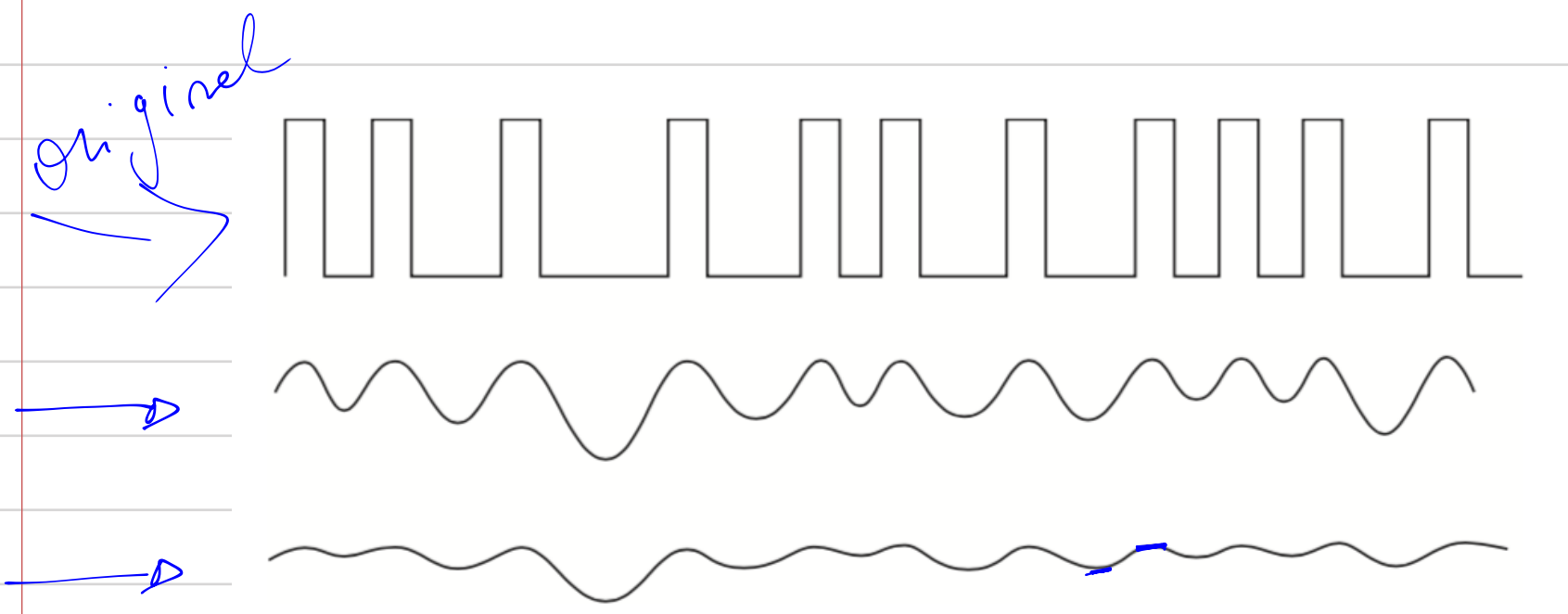


Figure 5.84 Rectangular pulses of light smeared out by increasing amounts of dispersion. Note how the closely spaced pulses degrade more quickly.