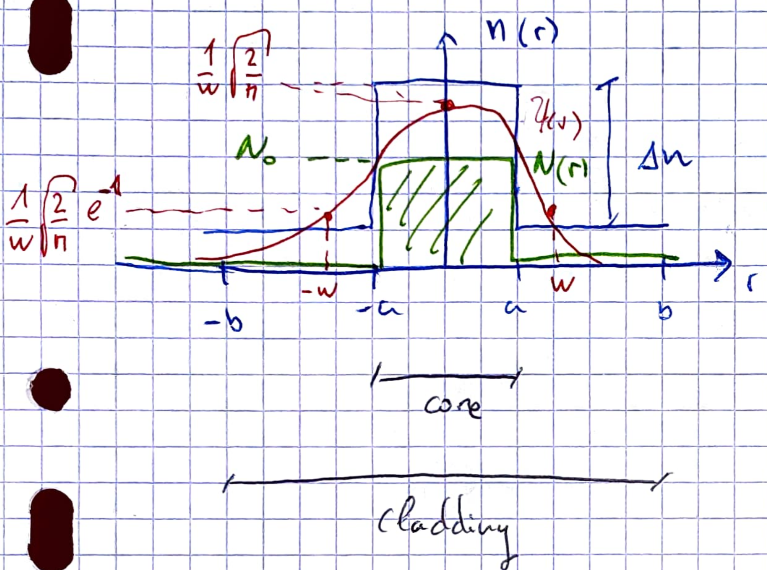
Tutorial 1 Correction

$NA = 0,21$

$a = 1,5\,\mu m$



N(r) doping profile

$N(r) = N_0$ if $|r| \leq a_d$

in our case $a_d = a$

but it's not mandatory

n(r) refractive index profile

$n(r) = n_1$ if $|r| \leq a$

$n(r) = n_2$ elsewhere

$\psi(r)$: distribution of electric field

- It is a gaussian
- $\psi(r) = \frac{1}{w}\sqrt{\frac{2}{\pi}}\,e^{-r^2/w^2}$

w → the waste

↳ if $r = w$

$$\psi(w) = \frac{1}{w}\sqrt{\frac{2}{\pi}}\,e^{-1}$$

maximum

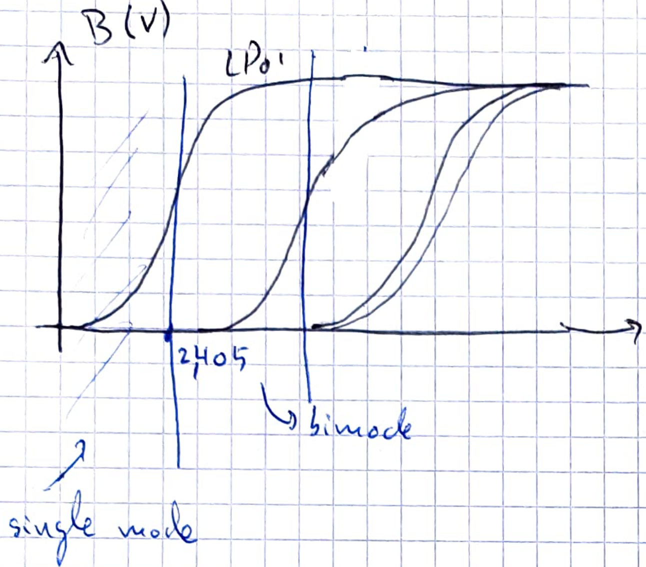
↳ ~~If w is smaller the confinamiento of~~

2 beams with different wavelengths will propagate in the medium

one long λ ⟶ signal

one short λ ⟶ pump

Can we propagate a single mode ∀ λ?



$V = \frac{2\pi}{\lambda} a\, NA$

$V < 2,405$

$V \nearrow$ if $\lambda \downarrow$ if a, NA are fixed

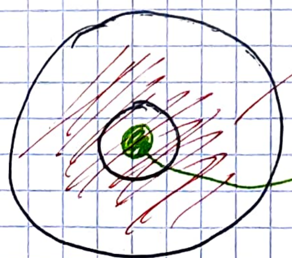
$V(\text{pump}) = \frac{2\pi}{0,98 \cdot 10^{-6}} \, 1,5 \cdot 10^{-6} \cdot 0,21 = 2,02 < 2,405$

The fiber is singlemode for the 2 wavelengths

(2)

Γ: overlap factor

$$\Gamma = \frac{\int_0^{2\pi}\int_0^{\infty} \frac{N(r)}{N_0} \Psi^2(r,\theta)\, r\,dr\,d\theta}{\int_0^{2\pi}\int_0^{\infty} \Psi^2(r,\theta)\, r\,dr\,d\theta} = \; \rightarrow *$$



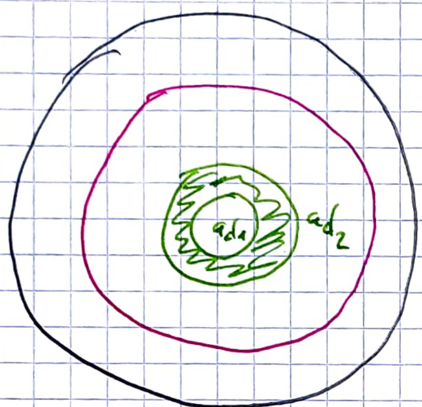
→ energy → calculando la integral en todo el espacio es toda la energía

→ fraction of energy interacting with ions

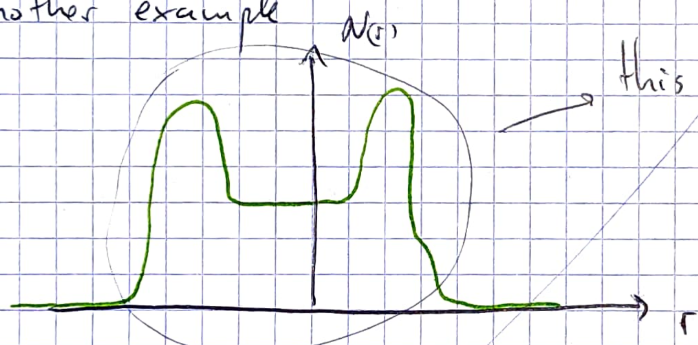
So if we  → Γ

$$(*) = \frac{\int_0^{2\pi} d\theta \left[\int_0^{a_d} \overset{\frac{N(r)}{N_0}}{1} \cdot \psi^2_{(r)}\, r\,dr + \int_{a_d}^{b} \overset{\frac{N(r)}{N_0}}{0} \cdot \psi^2_{(r)}\, dr \right]}{1} = (*)$$

Example of a different $N_{(r)}$



Another example

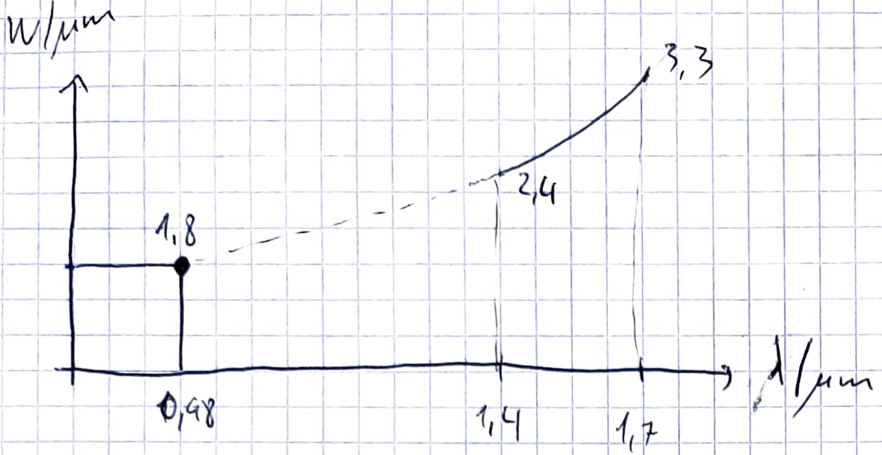


this we should put in:

$$\int_0^{2\pi}\int_0^{\infty} \frac{N(r)}{N_0}\, \psi^2_{(r)}\, r\,dr\,d\theta$$

$$(*) = 2\pi \int_0^{a_d} \psi^2\, r\,dr = 2\pi \frac{1}{w^2}\frac{2}{\pi} \int_0^{a_d} \left(e^{-r^2/w^2}\right)^2 r\,dr =$$

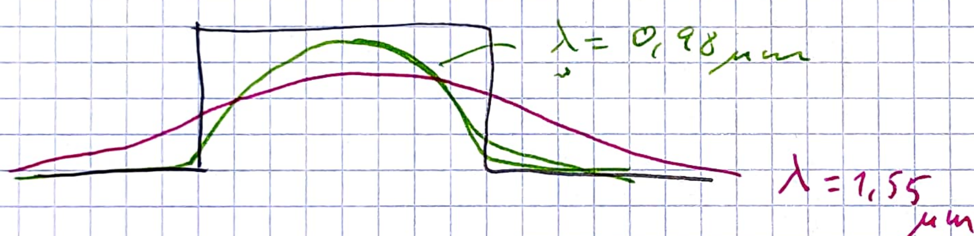
$$= \frac{4}{w^2} \int_0^{a_d} e^{-2r^2/w^2}\, r\,dr = 1 - e^{-2a_d^2/w^2}$$



$a_d = 1,9\,\mu m$

$\Rightarrow \Gamma = 0,75$ at $0,98\,\mu m$

$\Gamma = 0,4$ at $1,53\,\mu m$



1 mW at 1,55 μm

0,4 = 40% of the power will see the active ions

Marcuse formula $\quad 1,4 \leq V \leq 1,7$

$$W = a\left(0,65 + \frac{1,619}{V^{1,5}} + \frac{2,879}{V^6}\right)$$

the waste of the gaussian

radious