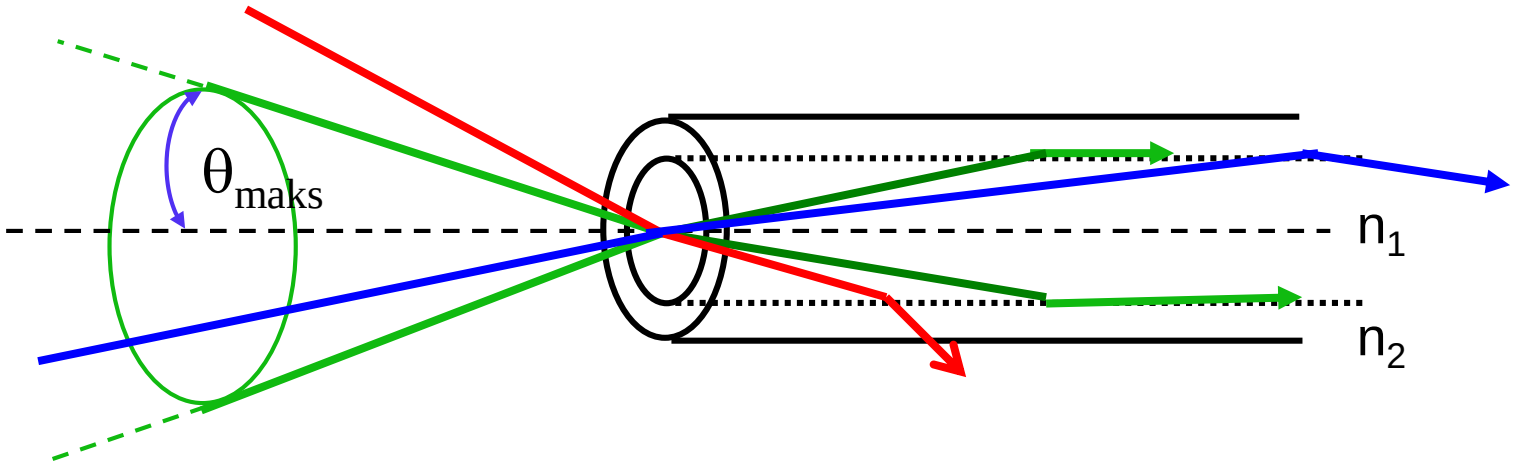
PENJALARAN CAHAYA DLM SERAT OPTIK

Step index fiber

Numerical Aperture (NA)



$$NA = \sin\theta_{maks} = \sqrt{n_1^{\,2} - n_2^{\,2}} = n_1\sqrt{2\Delta}$$

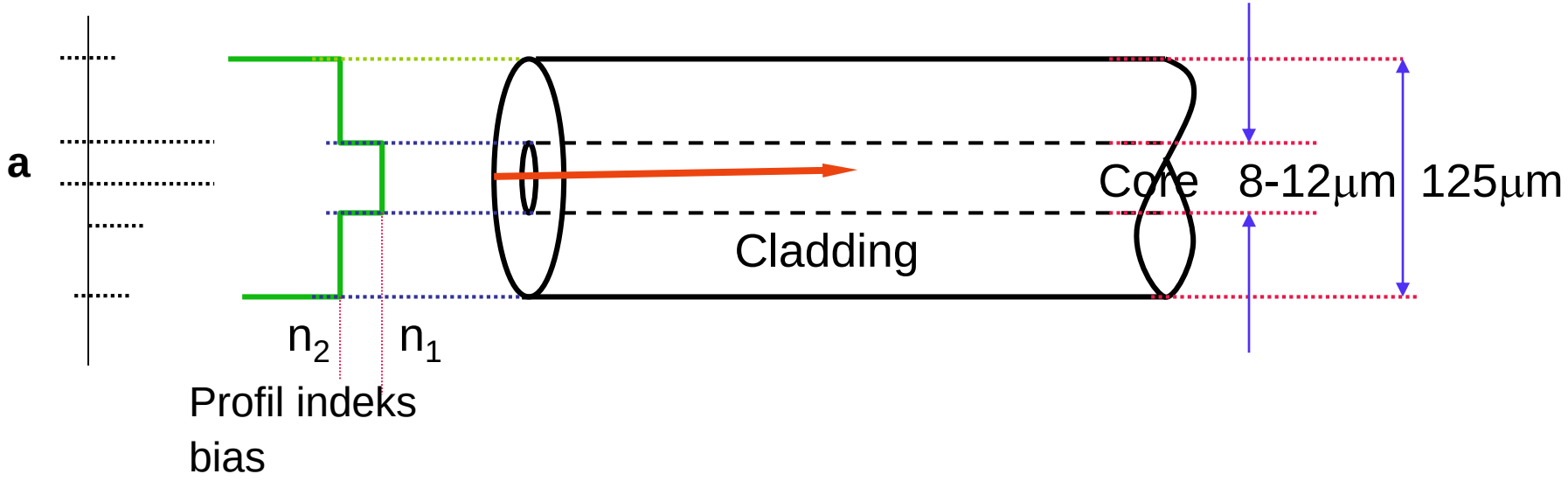
Δ : beda indeks bias relatif

$$\Delta = \frac{n_1^2 - n_2^2}{2n_1^2} \cong \frac{n_1 - n_2}{n_1}$$

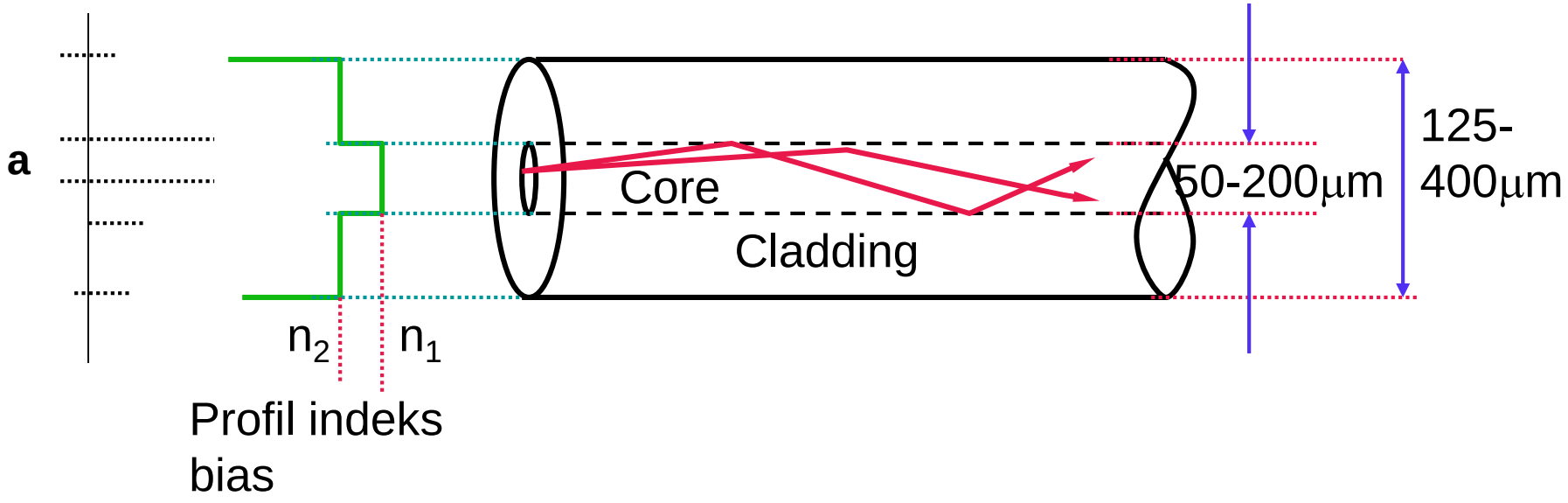
SI Fiber

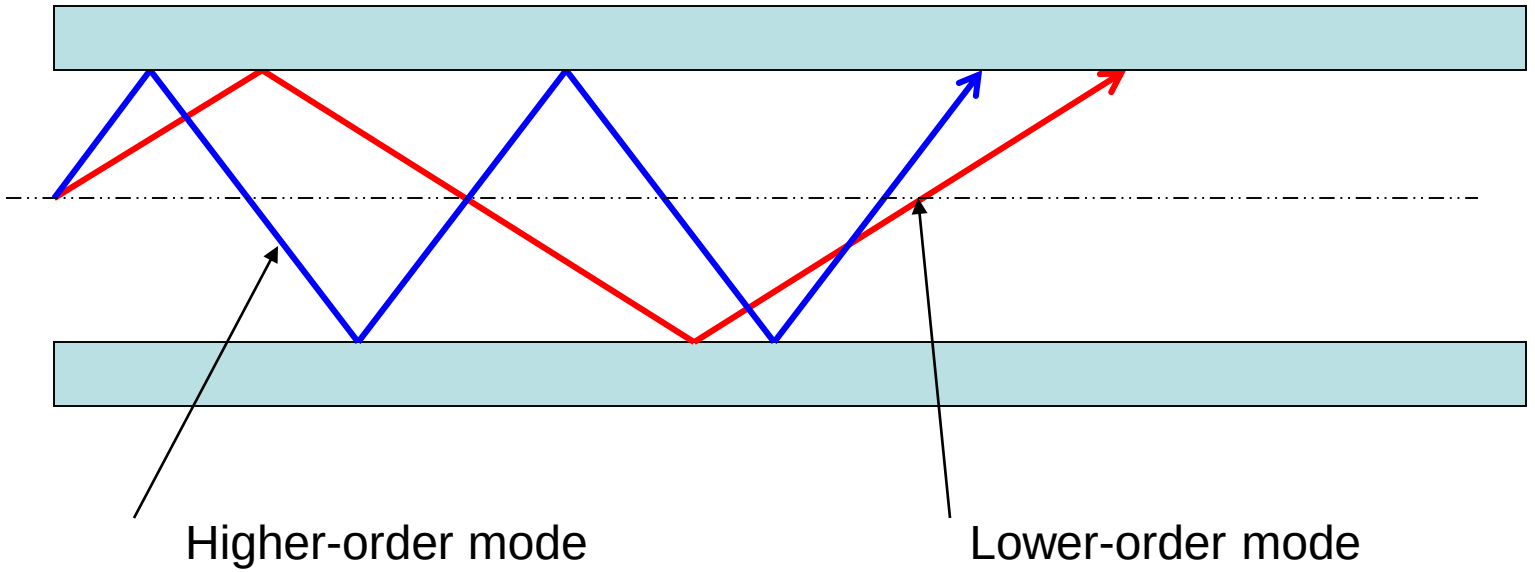
- Semakin besar sudut masuk ➔ semakin kecil sudut datang pd batas inti-kulit ➔ semakin panjang lintasan dlm serat optik.
- Cahaya menjalar dibedakan berdasarkan jumlah modus yg menjalar, semakin kecil sudut datang cahaya ➔ semakin kecil nomor modus cahaya yg menjalar.
- SO menyalurkan 1 modus ➔ single mode
- SO menyalurkan > 1 modus ➔ multimode

- Single mode Step Index



- Step Index Multimode





Representasi berkas multiple mode

V- parameter ➔ menentukan jumlah modus yg menjalar dlm SO

$$V = \frac{2\pi a}{\lambda}\sqrt{n_1^2 - n_2^2} = \frac{2\pi a}{\lambda} NA$$

Konstanta propagasi normalisasi b :

$$b = \frac{(\beta / k)^2 - n_2^2}{n_1^2 - n_2^2}$$

$$dengan$$

$$n_2 \le \beta / k \le n_1$$

$$k = 2\pi / \lambda$$

β : konstanta propagasi

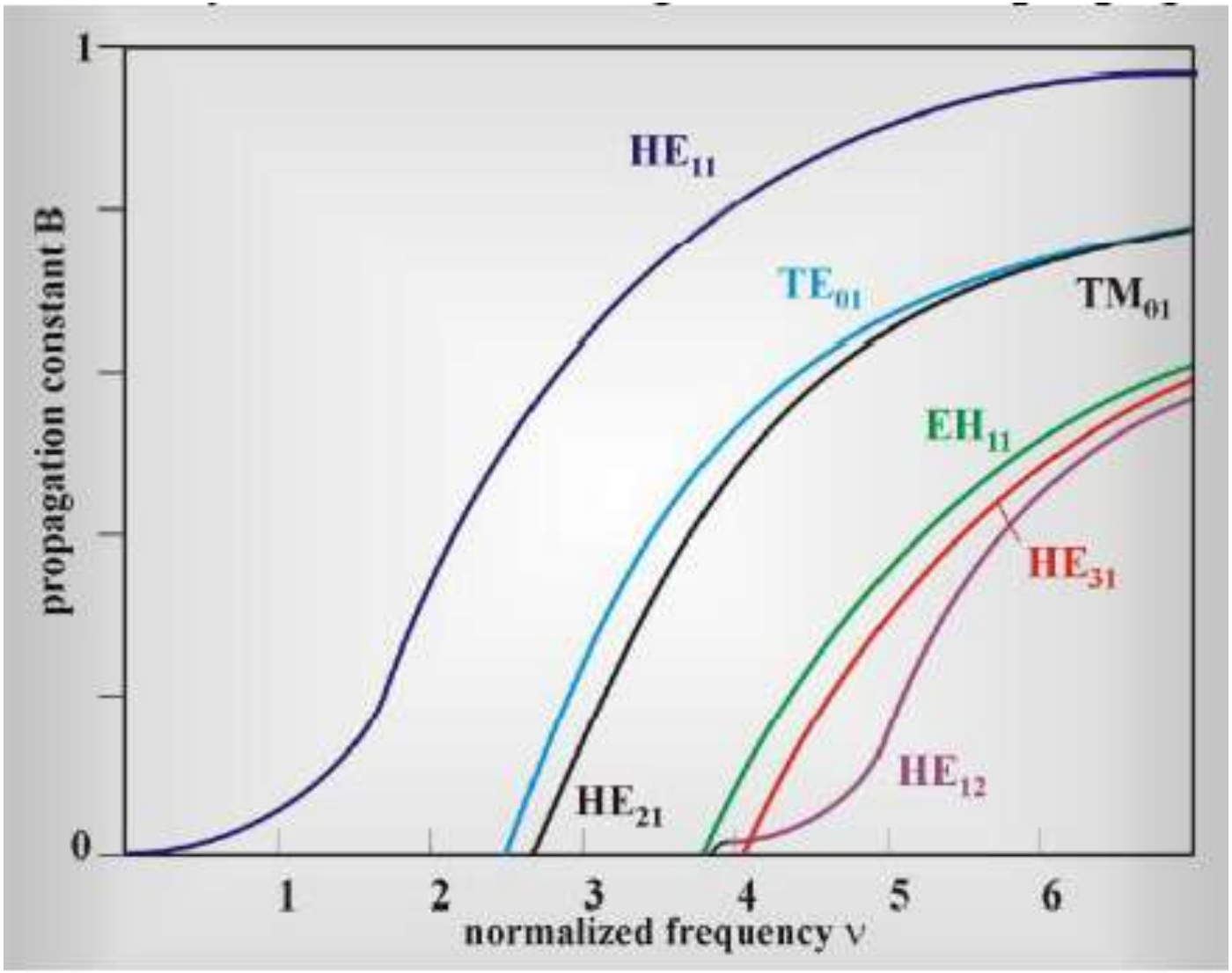
Mode cut off jika β/k = n_2

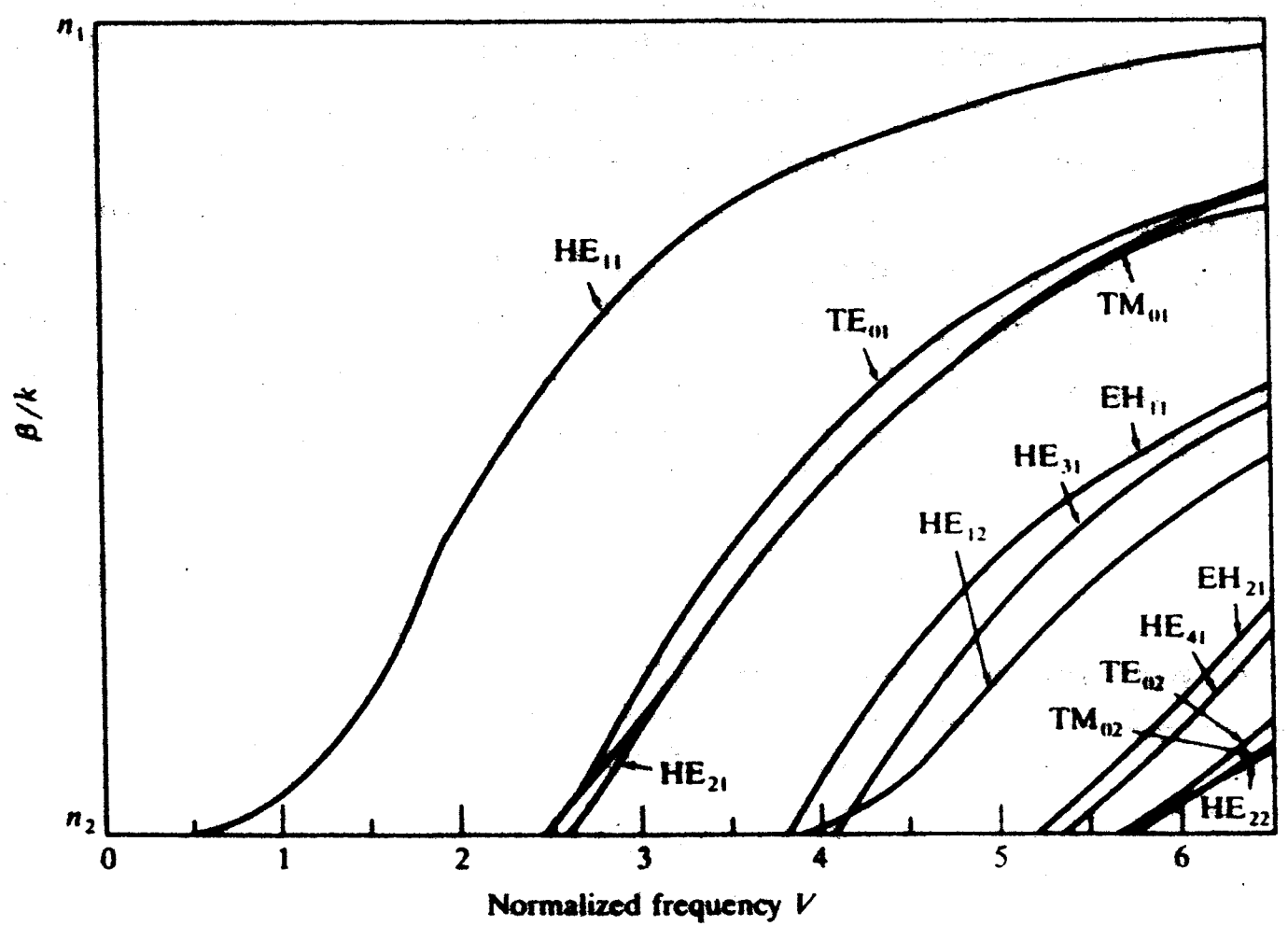
Single mode fiber : V ≤ 2,405

Atau V cut off : $V_C = 2{,}405$

Panjang gelombang cut off :

$$\lambda_C = \frac{2\pi a}{V_C}\sqrt{n_1^2 - n_2^2} = \frac{2\pi a n_1}{V_C}\sqrt{2\Delta}$$


1
0
propagation constant B
HE11
TE01
TM01
EH11
HE31
HE12
HE21
1
2
3
4
5
6
normalized frequency ν



Grafik β/k thd V utk beberapa modus orde terendah

V-Number and Fiber Modes

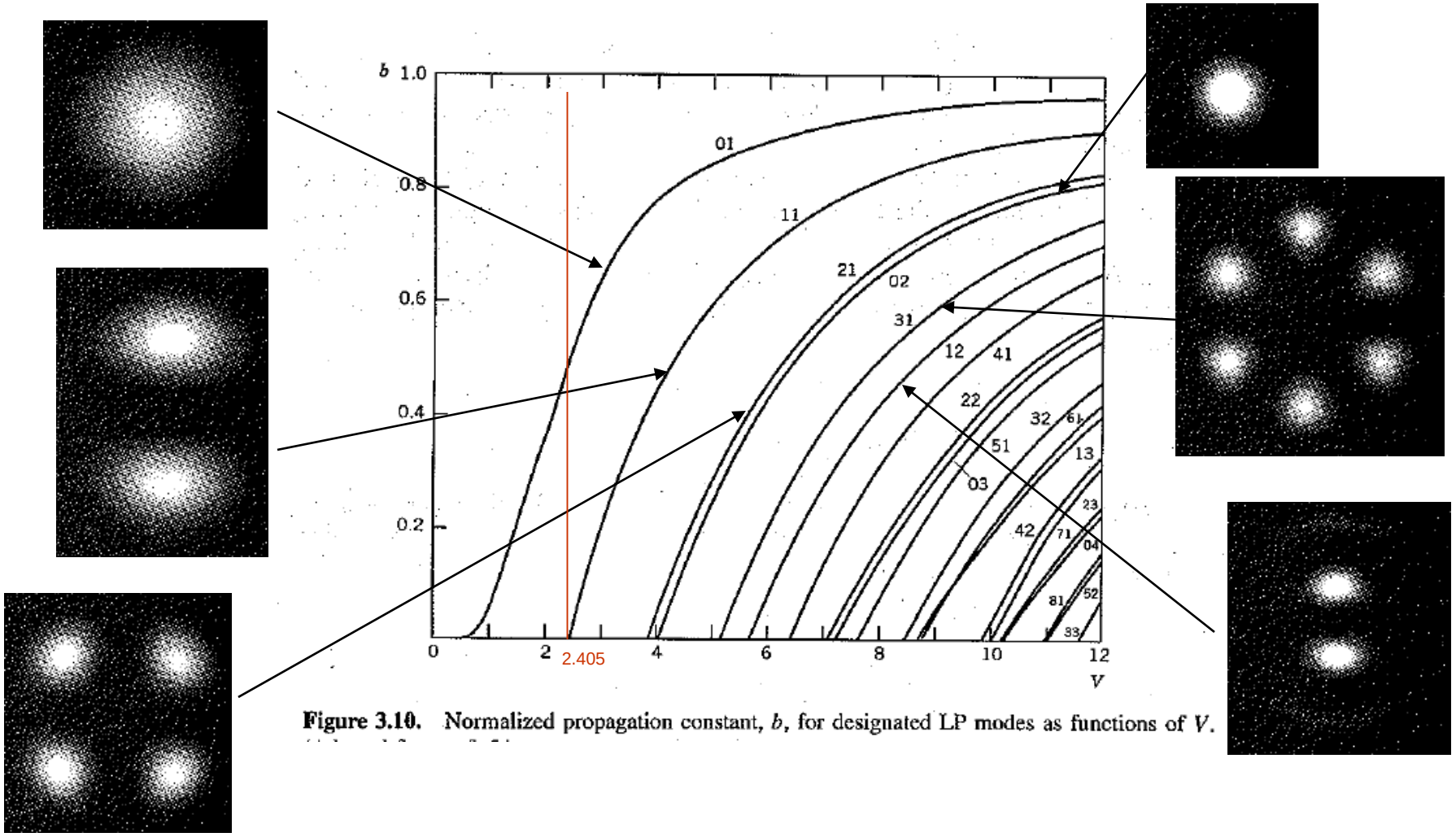
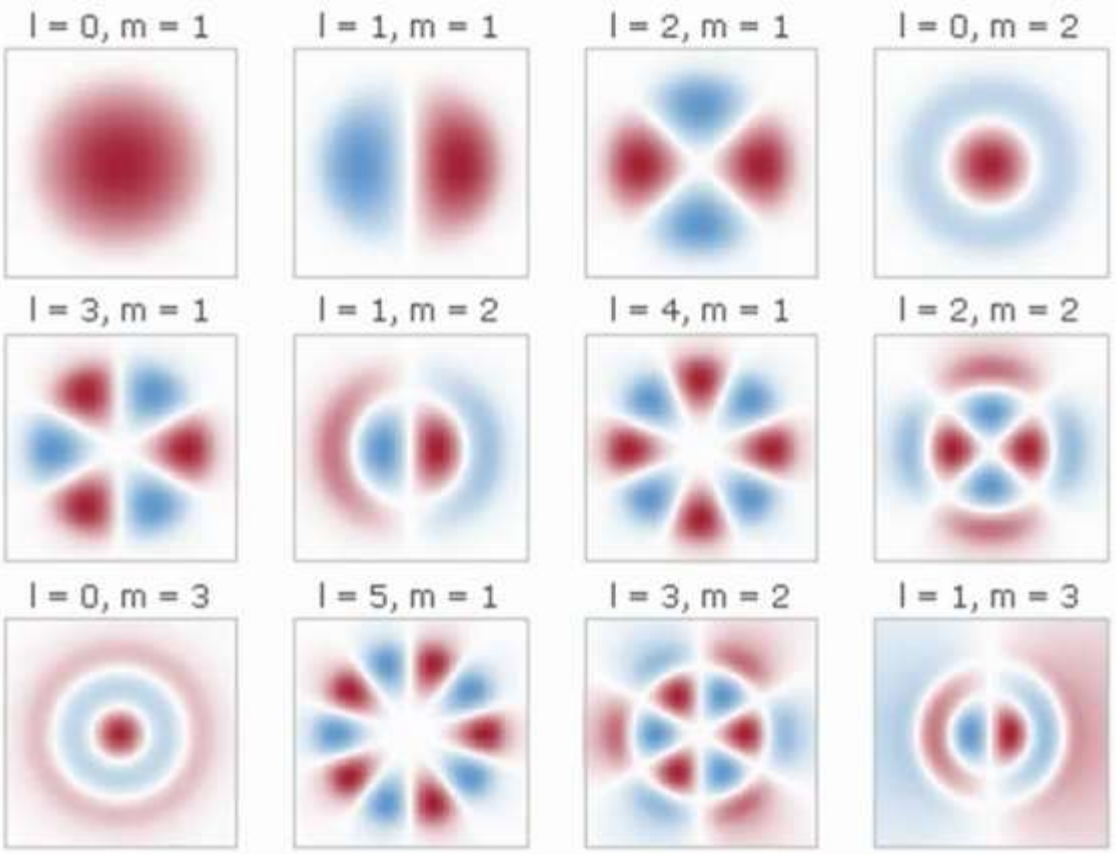


Figure 3.10. Normalized propagation constant, b, for designated LP modes as functions of V.

Fiber Modes



Solid acceptance angle dr fiber :

$$\Omega = \pi\theta^2 \cong \pi\left(n_1^2 - n_2^2\right) \quad \text{[Sterad]}$$

Jumlah mode yg masuk ke fiber :

$$M = \frac{2A}{\lambda^2}\Omega = \frac{2\pi^2 a^2}{\lambda^2}\left(n_1^2 - n_2^2\right) = \frac{V^2}{2}$$

Daya mengalir pd SI

$$\frac{P_{clad}}{P} = 1 - \frac{P_{core}}{P}$$

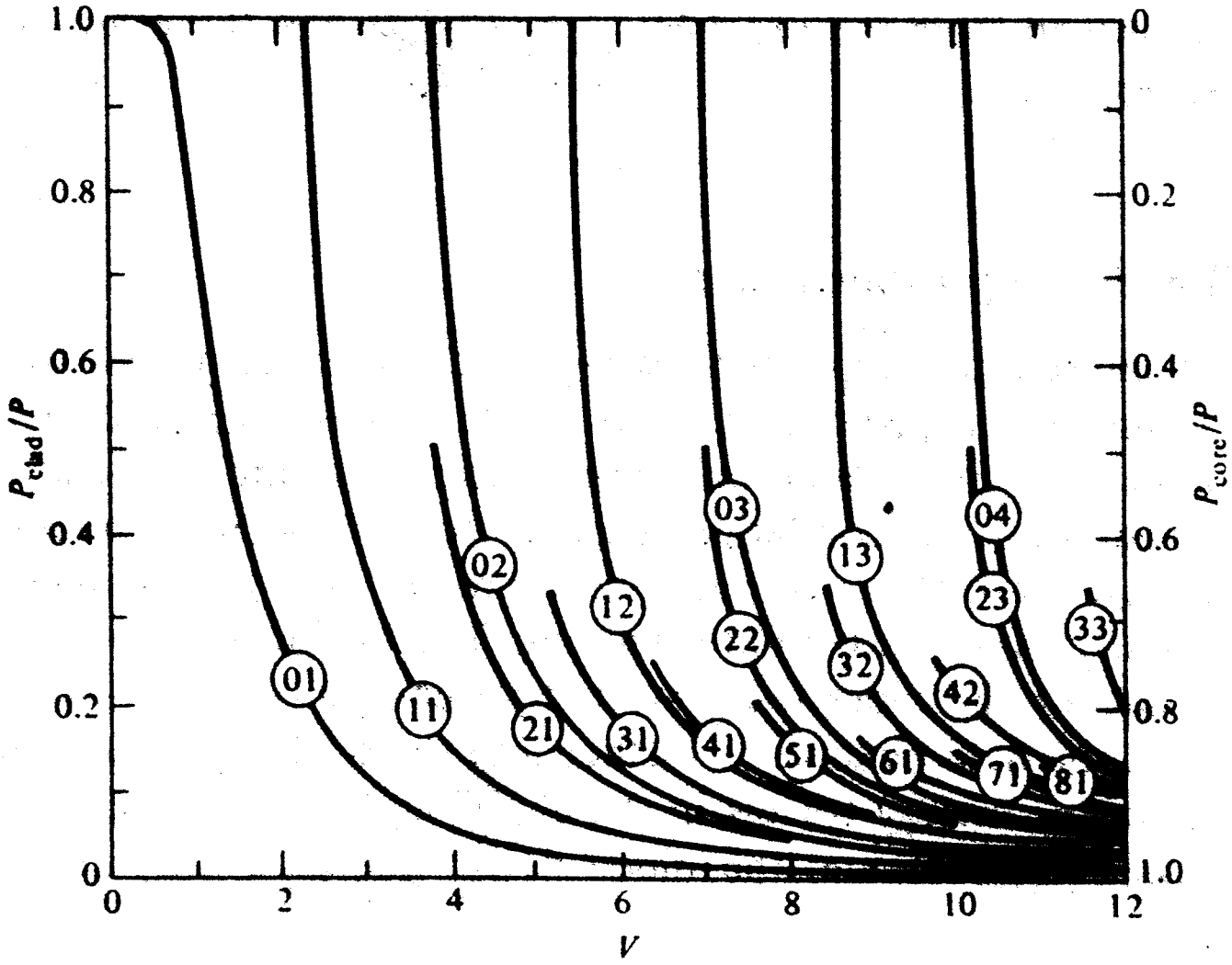
$$\left(\frac{P_{clad}}{P}\right) = \frac{4}{3} M^{-\frac{1}{2}}$$

Contoh :

Fiber step index a = 10 μm, n_1 = 1,48; Δ = 0,001; λ = 1,3 μm;

Hitung V; Ω; M; P_{clad}/P; λc;

Jika Δ = 0,03, hitung M dan P_{clad}/P;



Grafik aliran daya pd kulit dr fiber SI thd V

SM Fiber

Parameter penting/dasar dr SM fiber adalah MFD (Mode Field Diameter).

MFD ditentukan dr distribusi medan modus dr modus fundamental LP_{o1}.

Pada SM fiber tidak semua cahaya yg merambat pd fiber melalui inti.

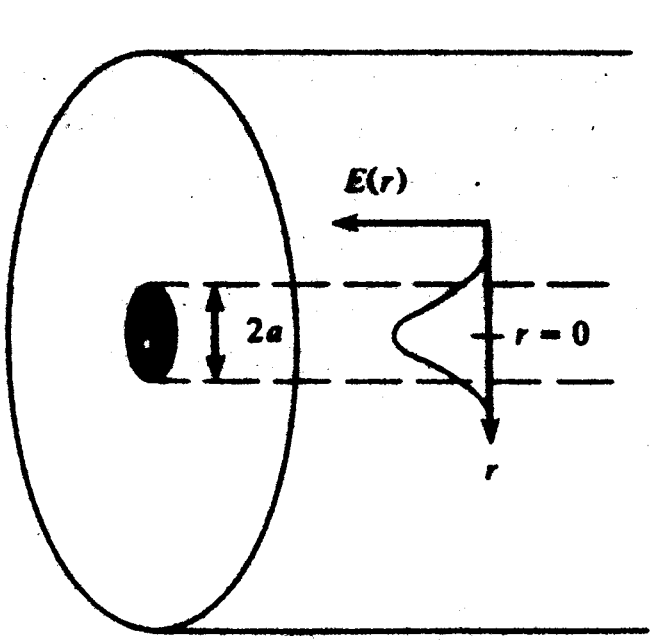
$$E(r) = E_o e^{-\left(\frac{r^2}{W_o^2}\right)}$$

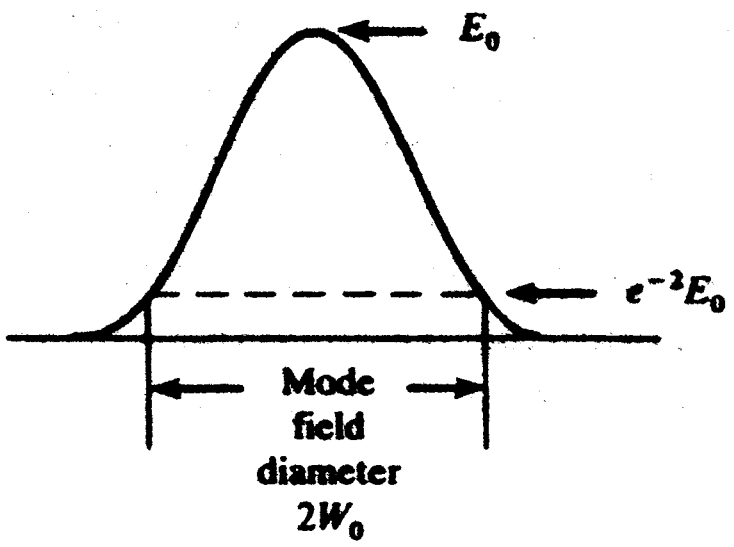
r : jari-jari

E_o : amplitudo medan listrik pd r =0

W_o : lebar distribusi medan listrik

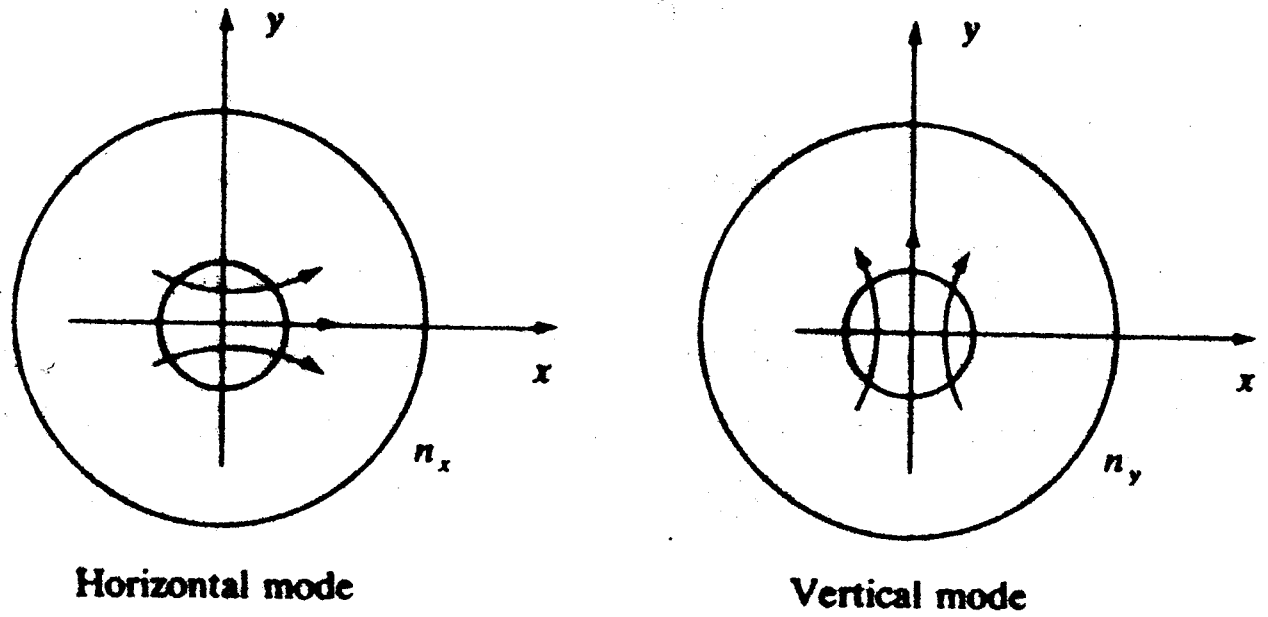
$$W_o = a(0.65 + 1.619V^{-3/2} + 2.879V^{-6})$$





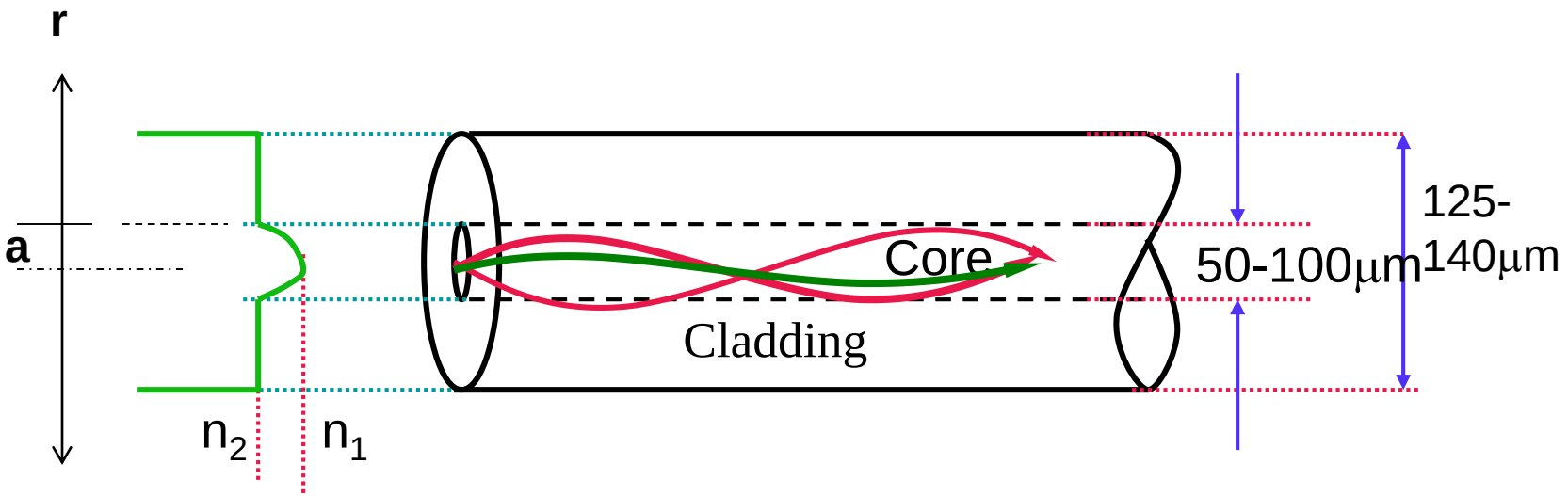
Distribusi cahaya di SM fiber diatas panj gel cut off-nya.

Utk distribusi Gaussian MFD sebesar lebar $1/e^2$ dr daya optis.



Dua polarisasi dr modus fundamental H_{11} pd fiber SM

- Graded Index



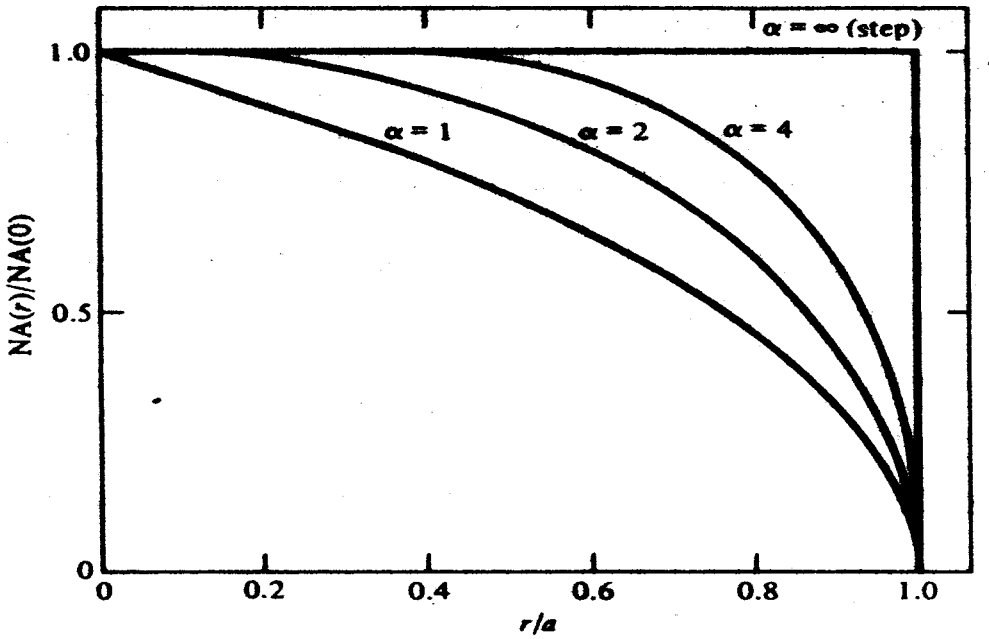
Profil Indeks bias

$$n(r) = \begin{cases} n_1\sqrt{1-2\Delta\left[\frac{r}{a}\right]^{\alpha}}\ ;\ldots\ldots\ldots\ldots 0 \le r \le a \\ n_1\sqrt{1-2\Delta} \cong n_1(1-\Delta) = n_2\ ;\ldots\ldots r \ge a \end{cases}$$

$$\Delta = \frac{n_1^2 - n_2^2}{2n_1^2} \cong \frac{n_1 - n_2}{n_1}$$

GI Fiber

$$\mathrm{NA}(r) = \begin{cases} \mathrm{NA}(0)\left[1-(r/a)^{g}\right] & \text{for } r < a \\ 0 & \text{for } r \geq a \end{cases}$$



Perbandingan NA dr fiber yg memiliki profil α yg berbeda

GI Fiber

Jumlah modus :

$$M = \frac{\alpha}{\alpha+2} a^2 k^2 n_1^2 \Delta = \frac{\alpha}{\alpha+2}\left(\frac{2\pi a n_1}{\lambda}\right)^2 \Delta$$

Utk V besar ➔ Jumlah modus $M = V^2/4$

atau setengah dr jml mode pd SI fiber

V cut off : $V_C = 2{,}405\sqrt{1+\frac{2}{\alpha}}$

Utk α = 2 pd GI :

➔harga V_C = 3,401 atau √2 kali lebih besar dr pd SI.

➔Harga λ_C akan 1/(√2) lebih pendek dr pd SI

Latihan :

Fiber graded index, $\alpha = 2$, $a = 10\ \mu m$, $n_1 = 1{,}48$; $\Delta = 0{,}001$; $\lambda = 1{,}3\ \mu m$;

Hitung n(r); NA(r); Vc; M; λc;