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Wybrane zagadnienia fotoniki

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semestr zimowy

Wykład 4

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L-1 p. 221

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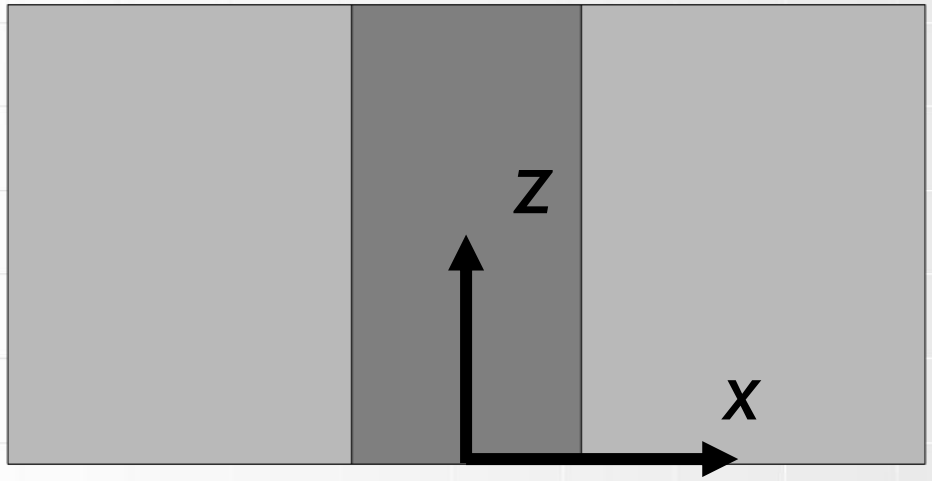
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Plan wykładu

- Propagacja światła w falowodach i włóknach optycznych
- Symetryczne falowody planarne
  - Mody TE
  - Mody TM
- Światłowody typu step-index
  - Klasyfikacja modów

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Mody symetrycznego falowodu planarnego



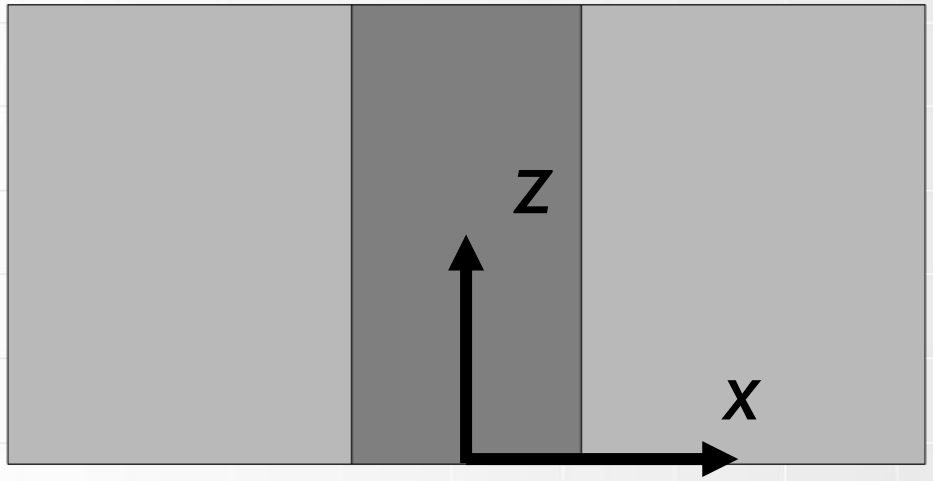
$$n(x) = \begin{cases} n_2, & \text{dla } |x| < \dfrac{d}{2} \\ n_1, & \text{w p.p.} \end{cases}$$

$$\nabla \times \mathbf{H} = i\omega\varepsilon_0 n^2 \mathbf{E},$$
$$\nabla \times \mathbf{E} = -i\omega\mu \mathbf{H}$$

$$\mathbf{E}(r,t) = \mathbf{E}_m(x)\exp\left[i(\omega t - \beta z)\right]$$
$$\mathbf{H}(r,t) = \mathbf{H}_m(x)\exp\left[i(\omega t - \beta z)\right]$$

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Mody symetrycznego falowodu planarnego



$$n(x)=\begin{cases} n_2, & \text{dla } |x|<\dfrac{d}{2} \\ n_1, & \text{w p.p.} \end{cases}$$

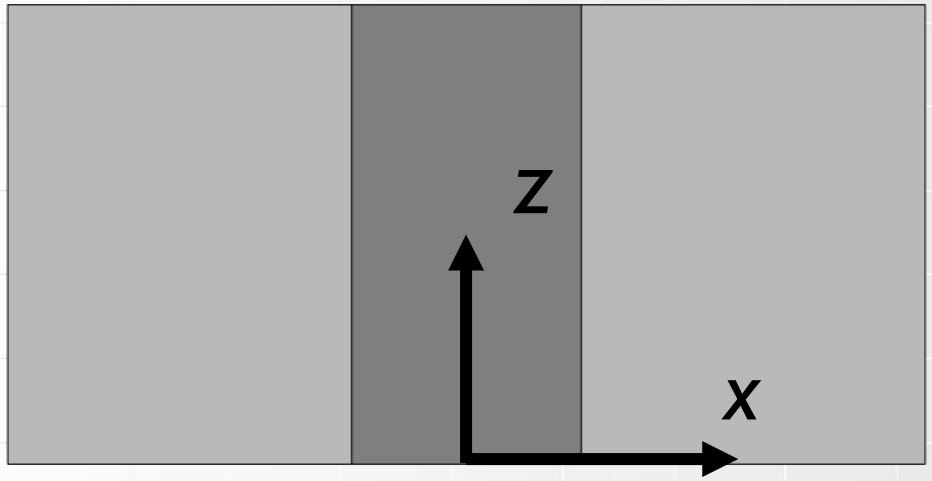
$$\mathbf{E}(r,t)=\mathbf{E}_m(x)\exp\left[i(\omega t-\beta z)\right]$$

$$\mathbf{H}(r,t)=\mathbf{H}_m(x)\exp\left[i(\omega t-\beta z)\right]$$

$$\left(\frac{\partial^2}{\partial x^2}+\frac{\partial^2}{\partial y^2}\right)\mathbf{E}(x,y)+\left[k_0^2 n^2(x)-\beta^2\right]\mathbf{E}(x,y)=0$$

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Mody symetrycznego falowodu planarnego - mody TE



$$n(x) = \begin{cases} n_2, & \text{dla } |x| < \frac{d}{2} \\ n_1, & \text{w p.p.} \end{cases}$$

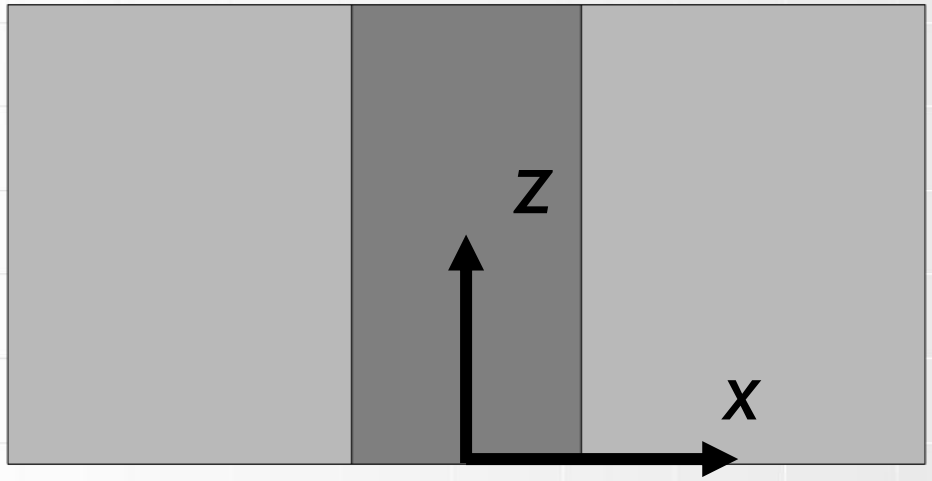
$$E_m(x) = \begin{cases} A\sin(hx) + B\cos(hx), & |x| < \frac{d}{2} \\ C\exp(-qx), & x > +\frac{d}{2} \\ D\exp(+qx), & x < -\frac{d}{2} \end{cases}$$

$$h = \sqrt{\frac{n_2\omega}{c} - \beta^2}$$

$$q = \sqrt{\beta^2 - \frac{n_1\omega}{c}}$$

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Mody symetrycznego falowodu planarnego - mody TE



$$n(x) = \begin{cases} n_2, & \text{dla } |x| < \frac{d}{2} \\ n_1, & \text{w p.p.} \end{cases}$$

$$u = \frac{1}{2} hd$$

$$v = \frac{1}{2} qd$$

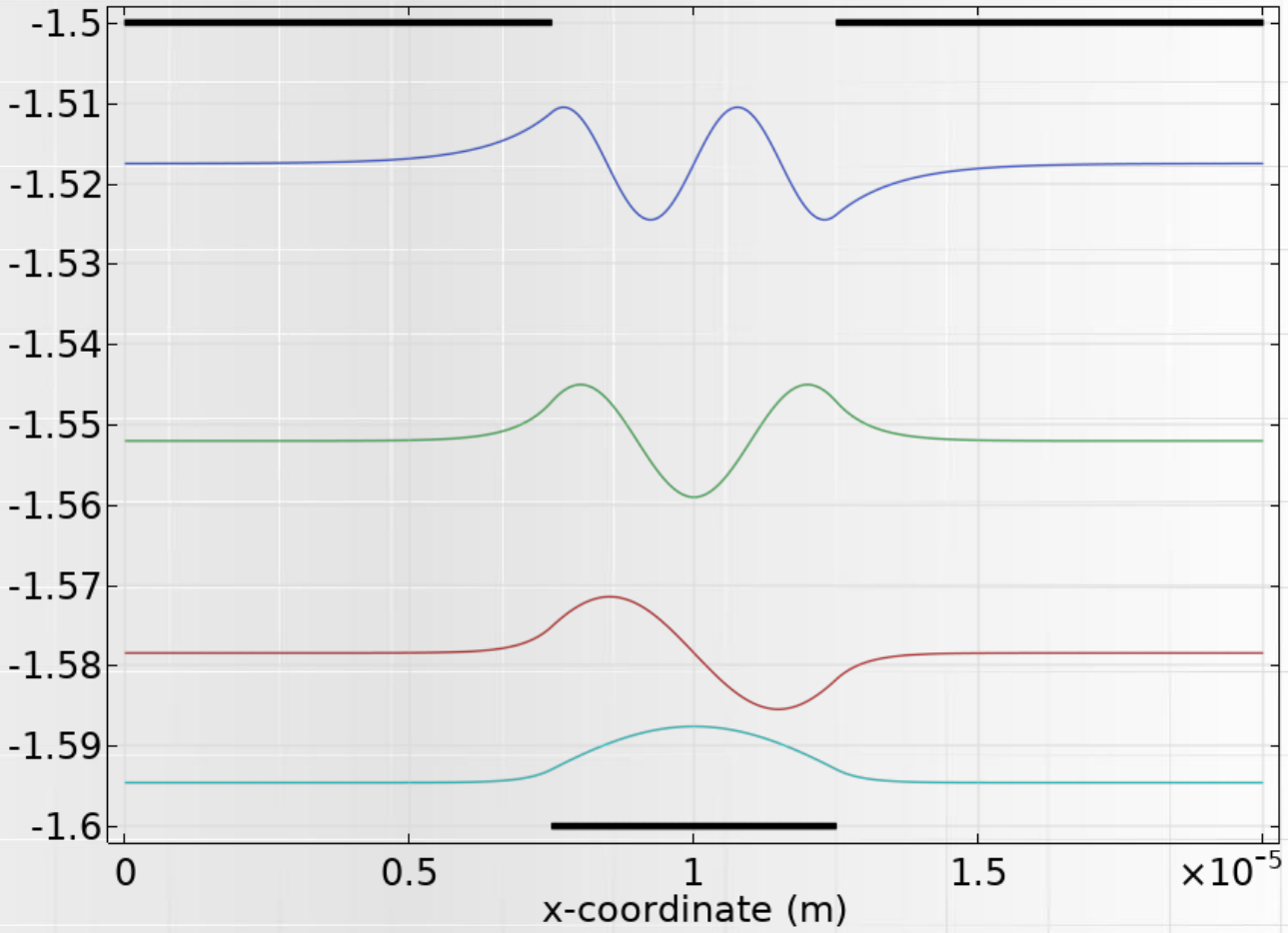
$$u^2 + v^2 = V^2$$

$$V \equiv \frac{\pi d}{\lambda} \sqrt{n_2^2 - n_1^2}$$

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Mody symetrycznego falowodu planarnego - mody TE

$$E_m(x) = \begin{cases} A\sin(hx) + B\cos(hx), & |x| < \frac{d}{2} \\ C\exp(-qx), & x > +\frac{d}{2} \\ D\exp(+qx), & x < -\frac{d}{2} \end{cases}$$



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Mody symetrycznego falowodu planarnego - mody TE

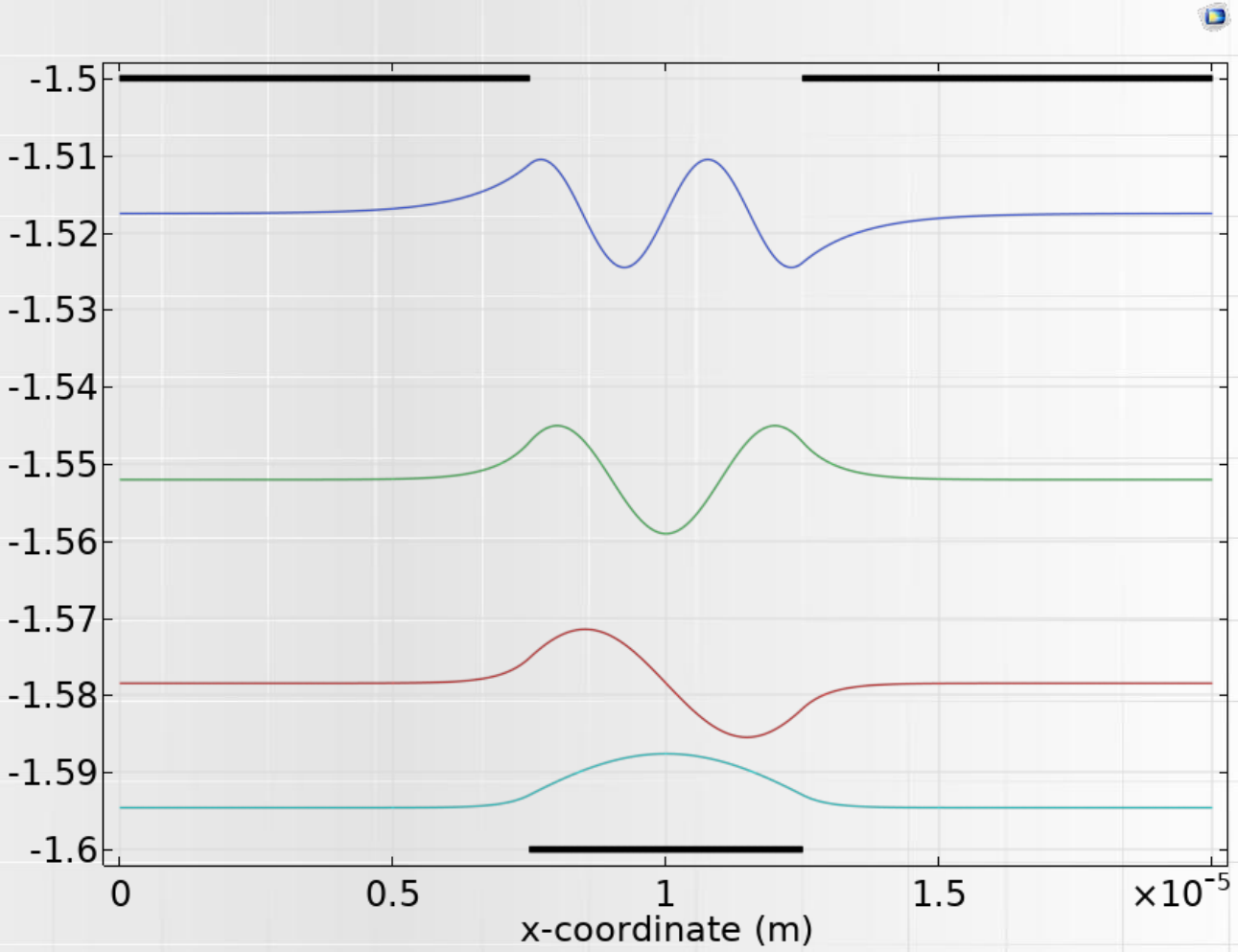
$$E_m(x) = \begin{cases} A\sin(hx) + B\cos(hx), & |x| < \frac{d}{2} \\ C\exp(-qx), & x > +\frac{d}{2} \\ D\exp(+qx), & x < -\frac{d}{2} \end{cases}$$

$\lambda = 1.55\ \mu m$ $\quad n_{TE_0} = 1.5946$

$d = 5\ \mu m$ $\quad n_{TE_1} = 1.5785$

$n_2 = 1.6$ $\quad n_{TE_2} = 1.5521$

$n_1 = 1.5$ $\quad n_{TE_3} = 1.5175$

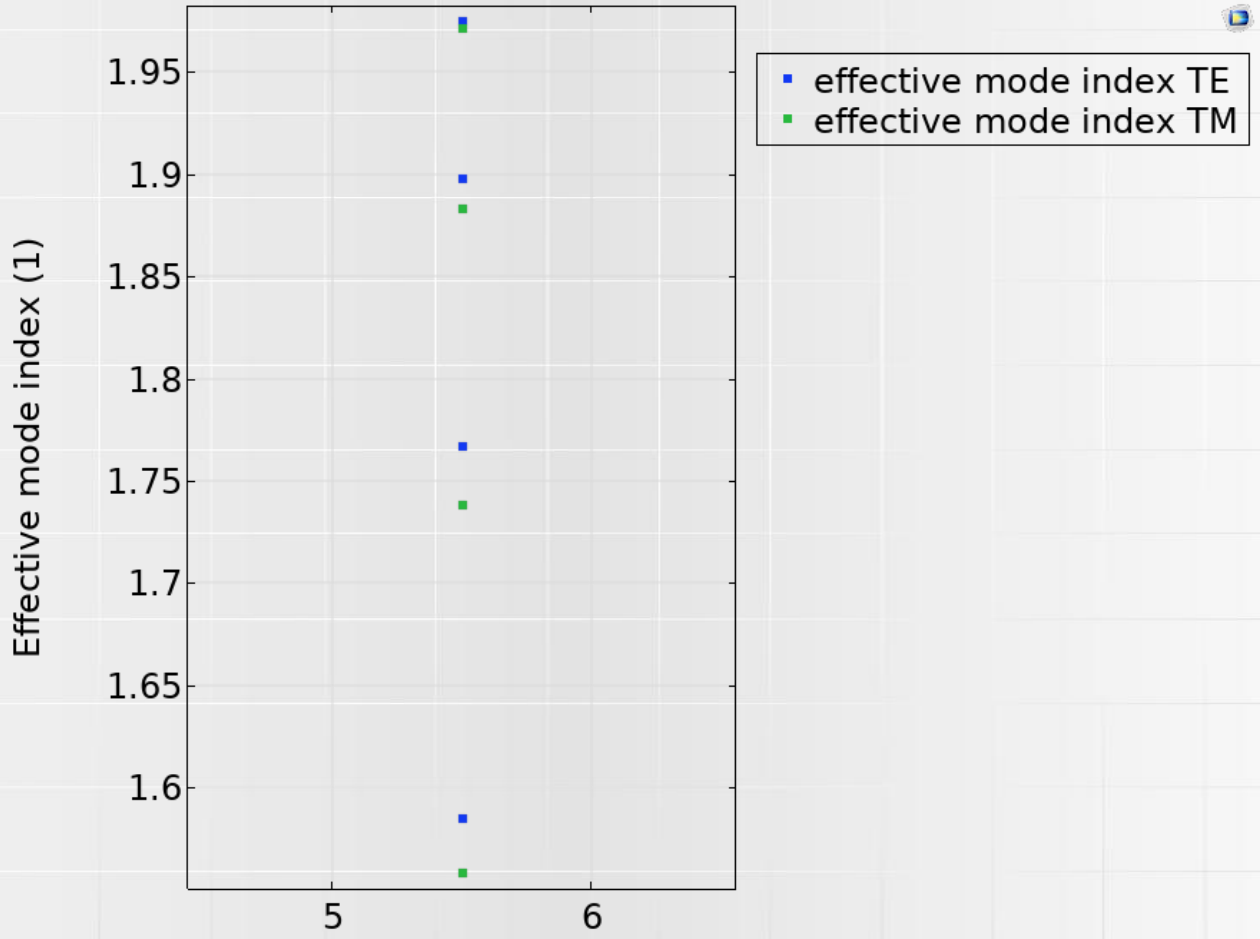


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Mody symetrycznego falowodu planarnego - mody TE/TM

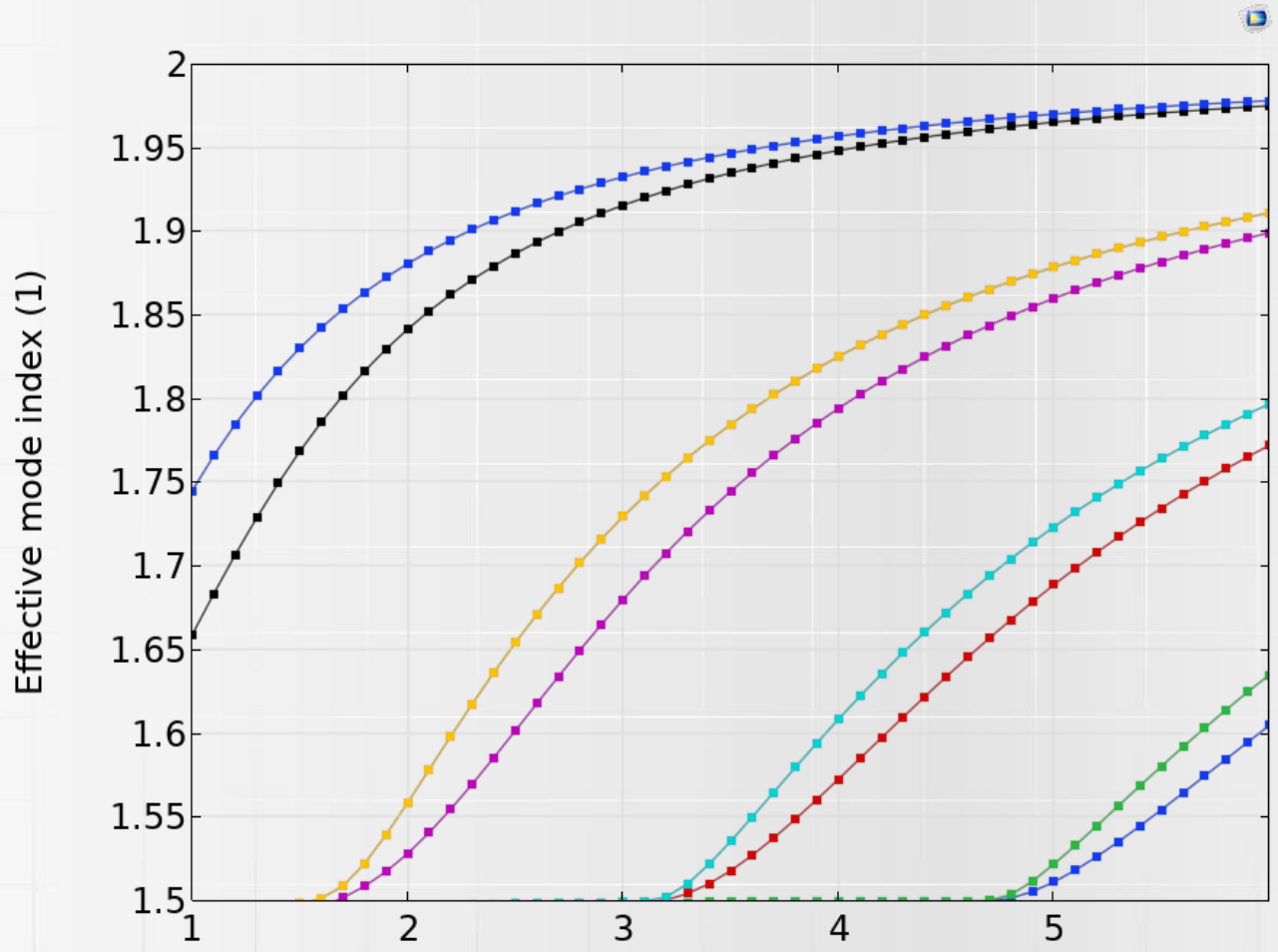
$n_2 = 2.0$

$n_1 = 1.5$



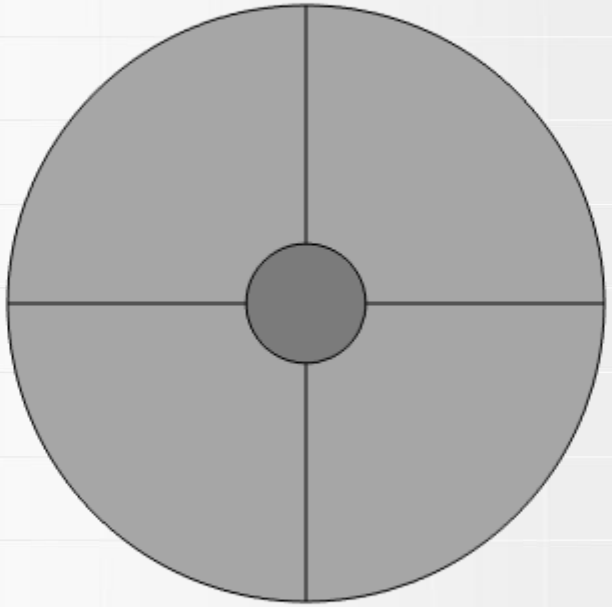
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Mody symetrycznego falowodu planarnego - mody TE/TM



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Światłowody step-index



$$n_1 = 1.4628$$

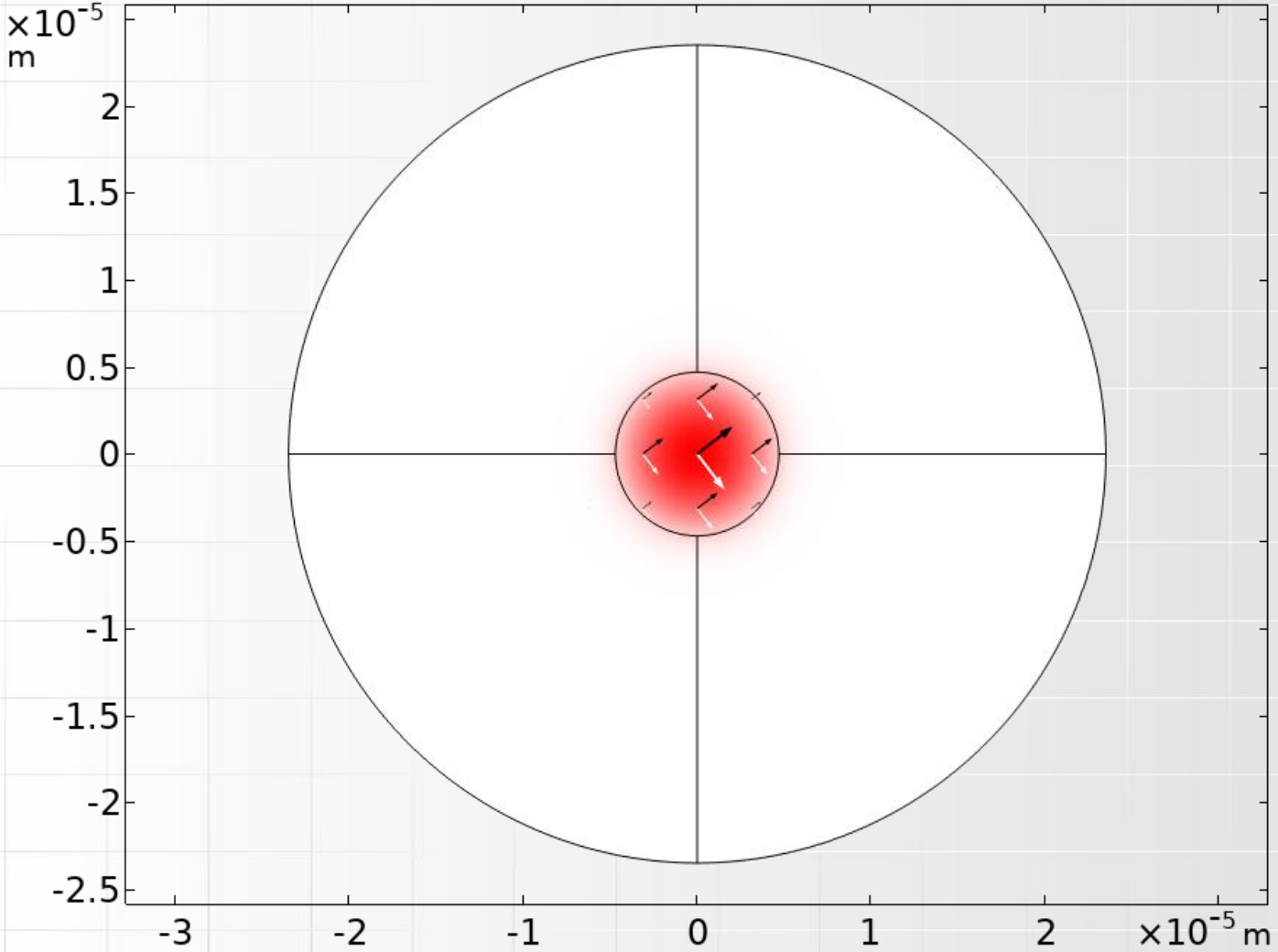
$$n_2 = 1.4600$$

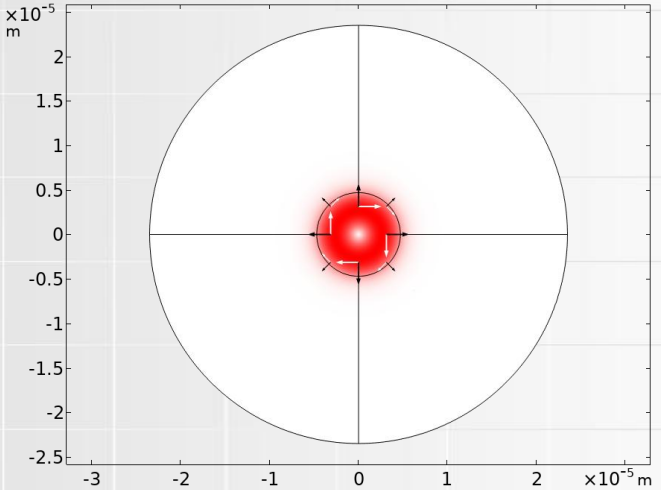
$$a = 4.7\ \mu\text{m}$$

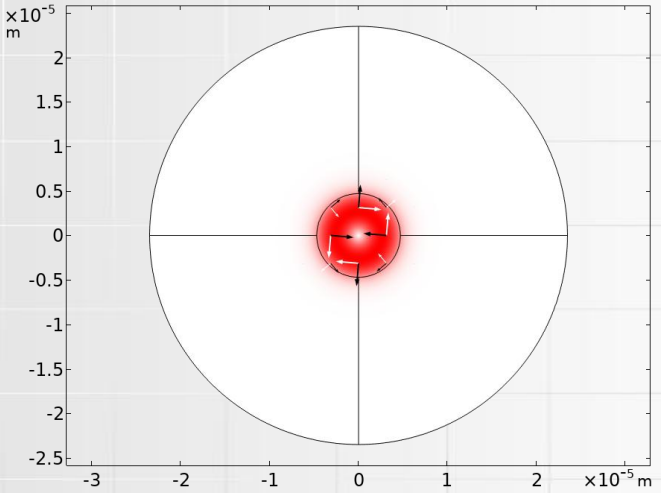
$$V \equiv \frac{2\pi a}{\lambda}\sqrt{n_2^2 - n_1^2}$$

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Światłowody step-index - klasyfikacja modów







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Podsumowanie

- Zagadnienia
  - Obliczenia typu: *Boundary Mode Analysis*
  - Obliczenia typu: *Mode Analysis*
  - Konfiguracja skanu po parametrze: *Parametric Sweep*

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Podsumowanie

- Propagacja światła w falowodach i włóknach optycznych
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