Total Internal Reflection

- Destructive interference
- Decaying fields
- Phase fronts
- Constructive interference
- Interference pattern
Light propagation

1. Rays can survive at discrete angles
2. There are finite number of rays

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\[ s_1 = \frac{d}{\sin \theta} \]

\[ s_2 = AD \cos \theta = (\cos^2 \theta - \sin^2 \theta) \frac{d}{\sin \theta} \]

\[ \frac{2 \pi n_1}{\lambda} (s_1 - s_2) + 2 \delta = 2 \pi m \]

\[ \frac{2 \pi n_1 d \sin \theta}{\lambda} + \delta = \pi m \]
Transverse Electric Mode

$TE$

Transverse Magnetic Mode

$TM$
Skew Rays

Hybrid Modes.
Low-order-mode fields

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Multimode fiber (MM) \( d \sim 50-100 \mu m \)

Single Mode fiber (SM) \( d \sim 6-8 \mu m \)

Cladding diameter = 125 \( \mu m \).
Graded Index Optical Fiber.
Comparison of fiber structures

Index Profile

Fiber Cross Section and Ray Paths

Monomode step-index fiber

Multimode step-index fiber

Multimode graded-index fiber

Typical Dimensions

125 μm (cladding)

8–12 μm (core)

125–400 μm (cladding)

50–200 μm (core)

125–160 μm (cladding)

50–100 μm (core)
\( \beta - \omega \) relation.

\[ V_p = \text{Phase velocity} = \frac{\omega}{\beta} \]

\[ V_g = \text{Group velocity} = \frac{\partial \omega}{\partial \beta} \]