Nanophotonic Modeling
Lecture 2.12: CAMFR Rationale

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CAMFR: Rationale

- Many problems consist of layers with varying widths
- Examples:
  - LED stack
  - Rod-hole photonic crystal
- Natural form of solutions is semi-analytic, in terms of eigenmodes

CAMFR: Basic Strategy

- Break up structure into layers
- Calculate eigenmodes in each layer (of four types)
- Apply Lorentz reciprocity to match BC’s
- Propagate within layers using S-matrix method
- Apply inputs to calculate physical outputs
CAMFR: Eigenmode Decomposition

• This stage resembles BPM
• Begin with the Helmholtz equation:
  \[ [\nabla^2 + \epsilon \mu \omega^2] \psi = \beta^2 \psi \]
• Where \( \psi \) represents \( E \)-field or \( H \)-field, and \( \beta \) is the eigenvalue (wavevector along \( z \))
• Write 3D solutions in this form for each layer:
  \[
  \begin{pmatrix}
  E(r) \\ H(r)
  \end{pmatrix}
  = \sum_k A_k e^{-j\beta_k z} \begin{pmatrix}
  E(r_t) \\ H(r_t)
  \end{pmatrix}
  \]
CAMFR: Eigenmode Decomposition


Can express eigenvalues in terms of $\text{Re } n_{eff}$ and $\text{Im } n_{eff}$
Eigenmode Classification

\[ \text{Guided mode} \quad \text{Im} \beta = 0; \text{discrete} \]

\[ \text{Complex mode} \quad \text{Im} \beta \neq 0; \text{Re} \beta \neq 0; \text{discrete complex-conjugate pairs} \]

\[ \text{Radiation mode} \]

\[ \text{Leaky mode} \quad \text{Im} \beta \neq 0; \text{Re} \beta \neq 0; \text{discrete} \]

\[ \text{Re} \beta = 0 \text{ or } \text{Im} \beta = 0; \text{continuous} \]