Tolerance Analysis of a Fiber Coupling Setup
Abstract

In modern optics, fibers can be found in various optical system, and it is usually of concern how much light can be coupled into fibers. The coupling efficiency can be sensitive to the system alignment, especially for single-mode fibers with relatively small core diameters. In this example, a well-designed fiber coupling lens is selected, and the coupling efficiency is evaluated with respect to different tolerance factors, such as the shift of fiber end position and the tilt of coupling lens.
Modeling Task

input field
- fundamental Gaussian
- wavelength 780 nm
- diameter 660 μm

Coupling lens (perfect alignment)

at designed incoupling position

single-mode fiber
- mode field diameter = 3 μm

Coupling efficiency $\eta = 99.1\%$

How does the coupling efficiency change with respect to alignment tolerance factors?

(a) shift of fiber end position

(b) tilt of coupling lens
Coupling Efficiency vs. Fiber End Position Shift

The coupling efficiency is scanned with respect to the fiber position shifts along both axial and lateral directions.

Contour plot helps with the identification of the parameter range for desired coupling efficiency threshold.
Coupling Efficiency vs. Coupling Lens Tilt

- **Physical-optics analysis of the coupling efficiency with respect to lens tilt.**
  - When lens tilt angle is within $0.2^\circ$, the coupling efficiency is still higher than 75%.
Peek into VirtualLab Fusion

multi-dimensional scanning of system parameters

visualization of coupling efficiency vs. tolerance factors
Workflow in VirtualLab Fusion

- Set up input Gaussian field
  - Basic Source Models [Tutorial Video]

- Load fiber coupling lens e.g. from Zemax file
  - Import Optical Systems from Zemax [Use Case]
  - find the optimal working distance
    - Optimal Working Distance for Coupling Light into Single-Mode Fibers [Use Case]

or, optimize your own lens in VirtualLab
  - Parametric Optimization of Fiber Coupling Lenses [Use Case]

- Use Parameter Run to scan over tolerance factors of concern
  - Usage of the Parameter Run Document [Use Case]
VirtualLab Fusion Technologies

- Free space prisms, plates, cubes, ...
- Lenses & freeforms
- Apertures & boundaries
- Gratings
- Diffractive, Fresnel, meta lenses
- HOE, CGH, DOE
- Micro lens & freeform arrays
- SLM & adaptive components
- Diffractive beam splitters
- Scatterer
- Diffusers
- Waveguides & fibers
- Nonlinear components
- Crystals & anisotropic components
- Single-mode fiber
- Coupling lens

1. Field Solver
2. Lenses & freeforms
3. Apertures & boundaries
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