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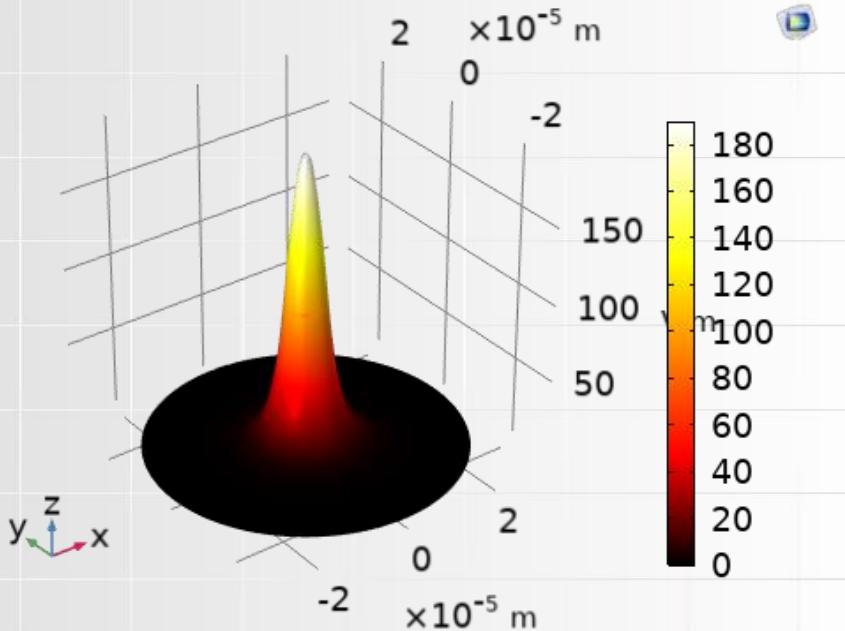
LaslonDef - Wrocław 2024

Photonic simulations using COMSOL

Hands on workshop



Part 1. Mode analysis optical fibers and waveguides



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Optical fibers - introduction

Optical fibers

- Optical fibers confine the light on the small area (order of tens of μm^2)
- Optical fibers can guide the light on the large distances (order of thousands of km)
- An optical fiber can support set of guided modes (one, few, many)
- Different physical mechanisms can be used to confine the light:
 - total internal reflection
 - modified total internal reflection
 - photonic bandgap



Optical fibers - numerical model

Input

- Wavelength
- Geometry of optical fiber
- Refractive index profile (material properties)

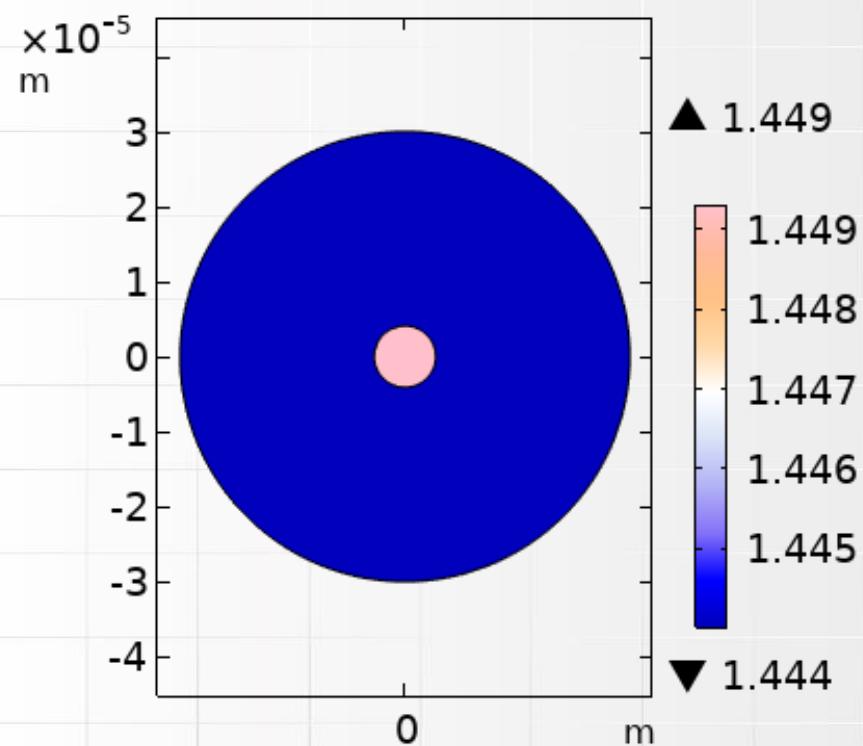
Output

- Effective refractive index
- Mode profile

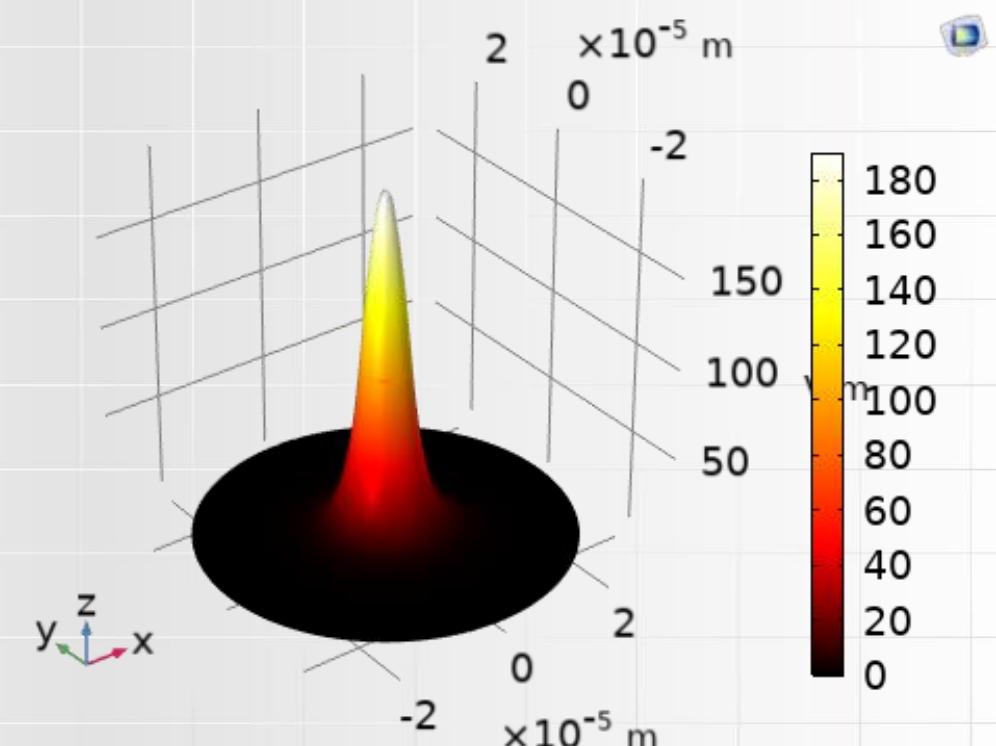


Optical fibers - numerical model

Refractive index profile



Electric field distribution of fundamental guided mode





Comsol Multiphysics

COMSOL

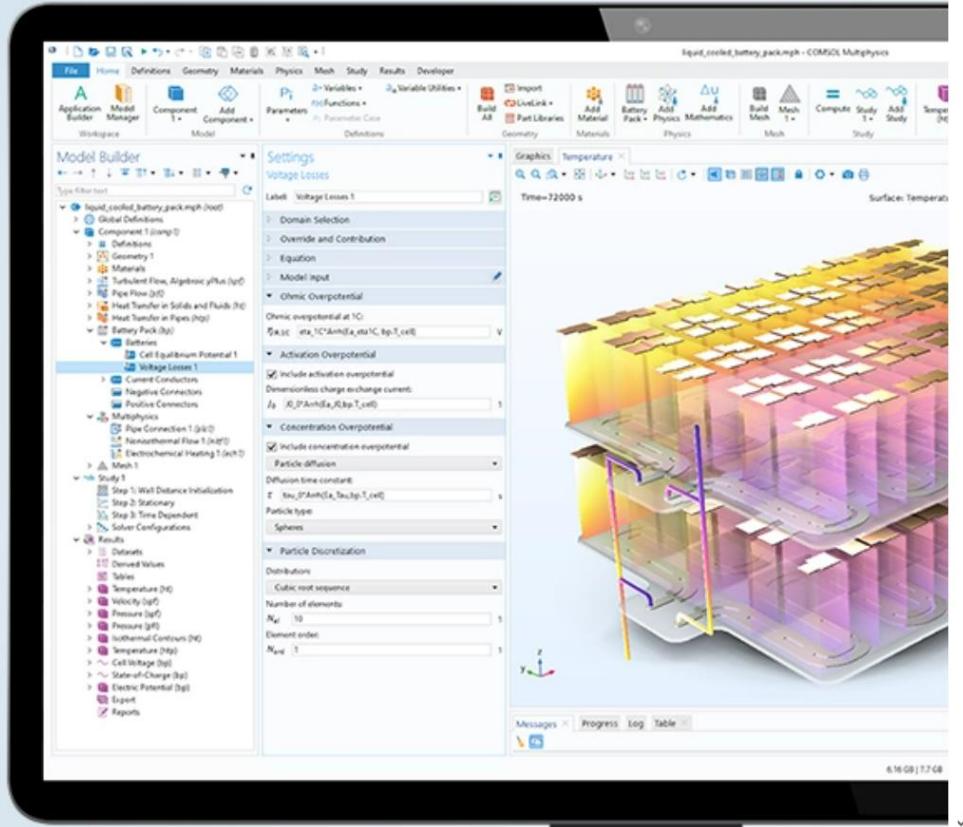
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- ✓ General-purpose simulation software based on advanced numerical methods.
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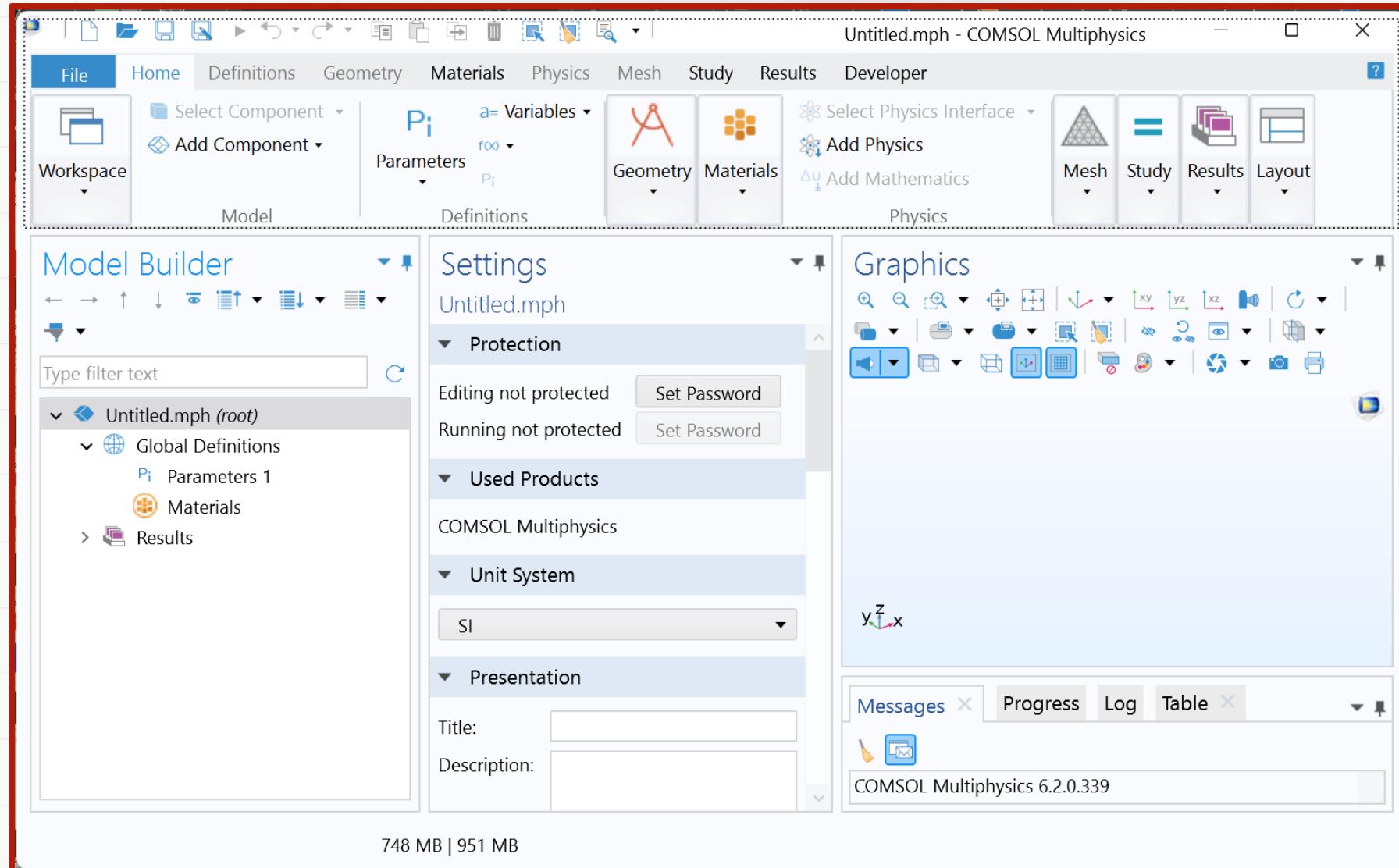
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Comsol Multiphysics





Comsol Multiphysics - Model Builder

Numerical model recipe

- Parameters
- Geometry
- Material properties
- Physics (problem definition)
- Mesh

Study

- Selected type of study steps

Results

- Postprocessing of obtained data

The screenshot shows the Comsol Multiphysics Model Builder interface. The left side features a tree view of the model structure:

- single-mode fiber.mph (root)
 - Global Definitions
 - Component 1 (comp1)
 - Definitions
 - Geometry 1
 - Materials
 - Electromagnetic Waves, Frequency Domain (ewfd)
 - Wave Equation, Electric 1
 - Perfect Electric Conductor 1
 - Initial Values 1
 - Mesh 1
 - Study 1
 - Step 1: Mode Analysis
 - Solver Configurations
 - Job Configurations
 - Results



Single-mode fiber

Light

- Wavelength

$\lambda = 1.55 \text{ } \mu\text{m}$

Fiber parameters

- Refractive index profile
- Core radius
- Core refractive index
- Cladding refractive index
- Refractive indices given at 1.55 μm

step-index

$r_{\text{co}} = 4.1 \text{ } \mu\text{m}$

$n_{\text{co}} = 1.4977$

$n_{\text{cl}} = 1.4440$

$n@1.55 \text{ } \mu\text{m}$



Outline

Setting up the mode analysis simulation
(geometry, material properties, boundary conditions)



Performing convergence tests (parametric sweep)



Using symmetries to reduce the problem



Scripting simulations using MATLAB LiveLink