Arti Agrawal – SH12 Finite Element Modelling Methods for Photonics

Numerical modelling and simulation of optical devices and components is a key tool in improving performance by reducing time and monetary costs, design optimization and characterization as well as innovating new ideas. Both passive and active devices are modelled and optimized numerically. In some cases simulation is the only way to explore phenomena where technology is not advanced enough for fabrication. The interaction of the optical beam with physical effects such as non-linearity, stress, strain, change in refractive index due to temperature, application of electric fields etc. are now extremely important. Modelling complements experimental work perfectly and almost no research is conducted without it.

The Finite Element (FE) method is one of the most popular and powerful methods for modelling in Photonics. This short course starts with Maxwell's equations and explains the basic principles of numerical modelling and the key assumptions involved. This foundation is used to develop the FE method, including a brief tour of the mathematics for determining propagating modes in waveguides. A discussion on using mesh and basis functions, boundary conditions (PML, periodicity, symmetry) and error dependence is included. The change in FEM accuracy with mesh and tradeoff between accuracy and computation time/resource is discussed. Tips on how to best make use of commercial solvers are also discussed in brief. The latter part of the course switches to showing examples simulated with FEM in commercial solvers and the course leader's own code through screen shots.

Some salient features of the short course include:

•Emphasis on practical application of FEM for modelling of devices

•Discussion on developing code/using commercial solvers

•Perfectly Matched Layer and Periodic boundary condition

•Generating mesh for structures, post-processing of results

•Discussion on popular commercial software such as COMSOL and how to best utilize them

Methods covered include:

•Full vector Finite Element method for modal solution

Practical illustrations include:

•Optical waveguides- finding modes

•Si slot waveguides, nanowires and high index contrast structures

•Bent waveguides and loss

•Plasmonic waveguides

- S parameters and their application to Anti reflection coatings, sensors