Comparison of different methods for rigorous modeling of photonic crystal fibers

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Abstract: We present a summary of the simulation exercise carried out within the EC Cost Action P11 on the rigorous modeling of photonic crystal fiber (PCF) with an elliptically deformed core and noncircular air holes with a high fill factor. The aim of the exercise is to calculate using different numerical methods and to compare several fiber characteristics, such as the spectral dependence of the phase and the group effective indices, the birefringence, the group velocity dispersion and the confinement losses. The simulations are performed using four rigorous approaches: the finite element method (FEM), the source model technique (SMT), the plane wave method (PWM), and the localized function method (LFM). Furthermore, we consider a simplified equivalent fiber method (EFM), in which the real structure of the holey fiber is replaced by an equivalent step index waveguide composed of an elliptical glass core surrounded by air cladding. All these methods are shown to converge well and to provide highly consistent estimations of the PCF characteristics. Qualitative arguments based on the general properties of the wave equation are applied to explain the physical mechanisms one can utilize to tailor the propagation characteristics of nonlinear PCFs.

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