

## Abstract

This thesis is devoted to rigorous numerical simulations of propagation characteristics of twisted and bend optical fibers. A recently developed full vectorial rigorous simulation method based on transformation optics formalism was used to conduct the simulations, which allowed, for the first time to our knowledge, to fully understand properties of the studied fibers. As a result, several new phenomena arising in twisted and bend optical fibers were identified.

In particular, the effect of fiber twist on effective indices, intensity profiles, polarization and confinement losses of the fundamental and the first-order modes was studied for the first time in helical core fibers. The obtained results differ significantly from the predictions of previously used approximate methods. Furthermore, the effect of coupling between core and cladding modes, which depends strongly on the fiber's symmetry, was studied in helical core fibers and double-helix fibers. The obtained results revealed the existence of a much richer resonance spectrum than that predicted by simplified perturbation approaches and showed the new effect of polarization perturbation of the core modes related to the couplings.

Furthermore, the surface plasmon resonance effect in helical core fibers with a cladding covered by a metal layer was analyzed for the first time. It was shown that the resonance loss can be amplified with a twist rate by more than two orders of magnitude. Moreover, new phenomena related to twist-induced change of coupling conditions between fundamental modes, surface plasmons and cladding modes were identified.

Additionally, the rigorous simulation method was used to examine the effect of fiber bending on spectral position and strength of the surface plasmon resonance in the microstructured fiber with metal inclusions. New fibers were designed, in which the surface plasmon resonance loss is in a high degree tunable by bending.

The results obtained in this thesis prove that twisted and bend fibers possess several previously undescribed features which allow for their novel applications in metrology and telecommunication. Additionally, it has been shown that these novel features can be observed only with the use of a rigorous method based on the transformation optics formalism as the previously used approximate methods ignore a part of significant effects and in some cases lead to incorrect results.