Experimental investigation of spatiotemporal nonlinear phenomena in multimode optical fibers

Keywords: multimode optical fibers, nonlinear fiber optics, four-wave mixing, soliton trapping, discretized conical emission, graded-index fiber, step-index fiber, photonic crystal fiber, space-time wavepackets

Abstract: This thesis work is devoted to the experimental characterization of nonlinear phenomena taking place in multimode optical fibers. The research hypothesis concerns how the dynamics of nonlinear phenomena with correlated spatial and temporal features can be governed by the input light properties. The dissertation begins with a general presentation of multimode optical fibers, and their parameters used to describe the nonlinear effects under study. The results and chapters are presented according to the increasing number of optical modes involved. The case of birefringent microstructured fibers supporting two polarization modes is studied first. In particular, pulse trapping and polarization conversion phenomena are analyzed through fiber group birefringence and orthogonal Raman scattering. Secondly, far-detuned nonlinear frequency conversion is investigated through intramodal and intermodal four-wave mixing processes in a few-mode graded-index fiber. Thirdly, the nonlinear propagation of ultrashort, intense pulses in a step-index multimode fiber highlights the spontaneous emission of discretized conical waves, which can be described as quasi-invariant space-time wave packets. Although distinct spatiotemporal nonlinear phenomena are involved in the systems considered, the spectral, spatial and temporal components of the output light are deterministically controlled by the modal composition of the input optical field. The obtained results contribute to the fundamental understanding of nonlinear phenomena in multimode optical fibers and pave the way for the control of new structured light states that could lead to exciting new research directions and applications.