Nonlinear dynamics in photonic systems is an effervescent field that has been continuously evolving during the last decades. The field of optical nonlinear dynamics can be divided in two subfields, namely the study of the temporal dynamics in nonlinear optical systems — assuming that the spatial structure of the light field does not change in time — and the study of spontaneous pattern formation in those systems. As an example of temporal dynamics, we refer to e.g. periodic or chaotic spike sequences that have been observed in the output of lasers. When considering the spatial extent of optical systems, a wealth of spatial patterns has been found in e.g. broad-area lasers and cells filled with sodium vapor. Most of these spatio-temporal phenomena encountered in optical systems can also be observed in a variety of other disciplines such as hydrodynamics, electrical discharges, chemical and biological systems, etc., because they refer to universal concepts and essentially share the same mathematical formalism. In this thesis, we address both temporal and spatial dynamics in optical systems.

In the first part of the thesis, we study the dynamical behavior of semiconductor ring lasers, presently recognized to be promising sources in photonic integrated circuits. In particular, the possibility of bistable directional operation has paved the way for encoding digital information in the emission direction of ring lasers.

The second part of this thesis deals with several selected topics in the field of spatially localized structures in extended systems, also referred to as dissipative solitons. Such solitons can appear spontaneously and exist due to the interaction of each part with its immediate surroundings in space.

Throughout the whole work, bifurcation theory and nonlinear dynamics are employed to (i) understand how the underlying physical parameters of the semiconductor ring laser influence its dynamical behavior and (ii) to unravel the fundamental principles and bifurcation structure of dissipative solitons.