# Guided wave interaction in photonic integrated circuits

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For already several decades a trend towards miniaturization of optical systems can be observed. Optical components with diverse functionalities are to be combined into single monolithic "chips". The field is called integrated optics, a subdivision of photonics. Concrete design efforts as well as fundamental investigations rely heavily on computer simulations. Analytical solutions, even for linear problems, exist only for few, highly symmetric, exceptional cases. One resorts to rigorous numerical methods, which very often lead to schemes with unacceptably large computational effort. Hence there is substantial interest in simplifying models for certain classes of problems.

We will focus on a quite general variant of what is known as coupled mode theory. The propagation and interaction of guided optical waves is to be predicted. Starting point is a physically reasonable field template. Typically this consists of a few known, most relevant modes of the optical channels in the structure, superimposed with coefficient functions of the respective — in principle arbitrary — propagation coordinates. Also the resonant eigenfields of optical cavities can be included, multiplied by single unknowns. Discretization of the unknown functions into 1-D finite elements leads to an approximation of the optical field in terms of a linear superposition of structure-adapted, more or less localized modal elements. By means of a projection procedure of Galerkin type, or alternatively by variational restriction of a functional representation of the full 2-D/3-D vectorial first order Maxwell equations in the frequency domain (with transparent influx boundary conditions for inhomogeneous exterior), one can then reduce the problem to a small- to moderate-sized system of linear equations. A series of 2-D examples, including a crossing of dielectric waveguides, waveguide Bragg gratings, and circuits of micro-ring or -disk resonators, illustrate the performance of the approach.