Nonlinear Switching Effects in Coupled Micro-photonic Cavities

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Abstract— Nowadays high-quality micro-cavities are established in several systems, such as photonic crystals, disks or photonic wire rings. Fabrication of multiple coupled cavities has also provided a path towards advanced filters or long delay lines. Here we explore some of the nonlinear effects, which appear when these resonators are coupled to each other.

One of the important issues concerning photonic switching is the lowering of necessary input powers. By judiciously choosing the waveguide distance between two cavities it is possible to establish extremely sharp peaks in the transmission spectrum. Numerical results show that this leads to very low power switching possibilities.

Besides these more traditional interference effects, the coherent feedback provides other opportunities, such as symmetry breaking. One starts with a left-right symmetric structure with equal inputs from left and right. Under certain conditions, it turns out that the symmetric solution destabilizes, if one increases the input power. This leads to asymmetric states, where more output power exits to one side than to the other. Switching between output directions is possible by adding pulses to the correct inputs, which results in optical flip-flop behavior.

Recently we optimized this scheme by using 'blockers' next to the cavities, which lead to Fano resonances, in order to lower the power required for the bifurcation. In addition we extended the scheme towards a circuit of three cavities. This three-cavity structure provides rich dynamics, and functions as a tri-stable integrated memory device.

All these structures are efficiently examined using coupled-mode theory. Conditions for symmetry breaking are derived analytically. These studies are confirmed with rigorous numerical simulations, using finite-difference time-domain and eigenmode expansion methods. Because the concepts are general, they can be implemented in several micro-photonic platforms, such as photonic crystals or photonic wires.

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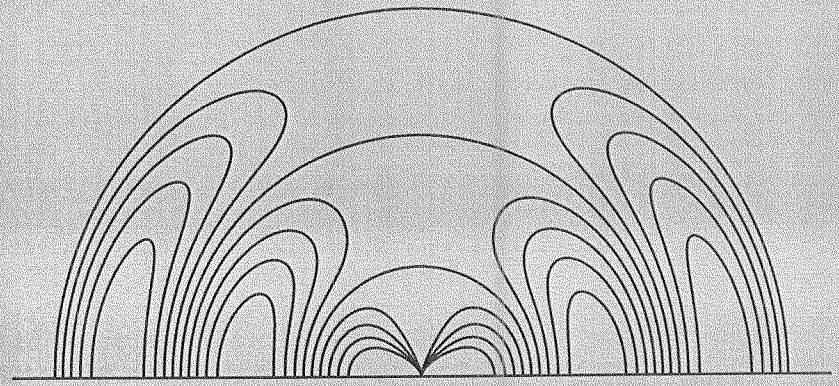

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