Coupled-waveguide arrays: oblique injection & soliton propagation

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The interaction between light beams and periodically-patterned host materials (such as coupled-waveguide arrays or photonic crystals) is a fundamental class of problem in nonlinear optics [1,2]. While oblique (off-axis) propagation effects play a central role in both these configurations (and lie at the heart of photonic device architectures generally), such considerations have been largely absent from the literature to date. In this presentation, we propose a new nonparaxial model capable of describing arbitrary-angle evolution of scalar beams in periodic optical systems. By retaining a more complete governing equation that is naturally of the inhomogeneous Helmholtz class [3,4], we have been able to capture configurations whereby, in the *laboratory frame*, the incident light beam may be inclined at any arbitrary angle with respect to the waveguide array. Simulations involving these geometrical considerations (see Fig. 1) reveal that oblique propagation across a patterned optical structure involves elements of both coupled-waveguide and photonic-crystal physics. Paraxial theory, rooted firmly in the traditional nonlinear-Schrödinger formalism (with its slowly-varying envelopes and small-angle limitations), obscures such a connection [1,2].

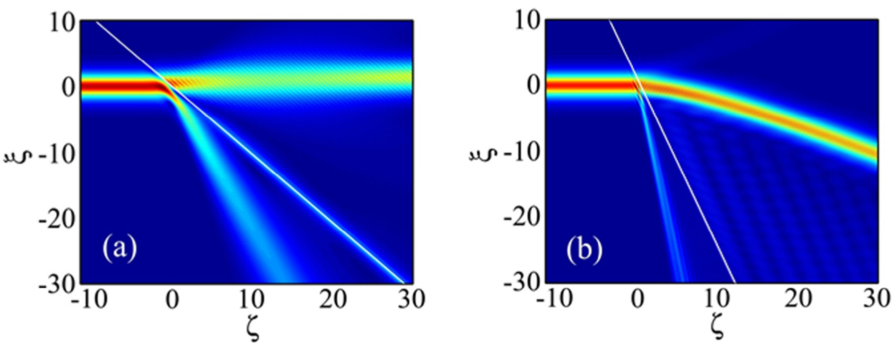

Figure 1. Side-coupling of a spatial soliton into a waveguide array with a periodically-patterned linear refractive index (the boundary between the two media is denoted by the white line). (a) At a quasi-paraxial incidence angle of 4.5° (in the laboratory frame) a significant proportion of incident energy is reflected and there is strong excitation of a stable surface wave. (b) At a nonparaxial incidence angle of 10.0° (in the laboratory frame), there are qualitatively new phenomena (here, an asymmetric radiation pattern and the absence of a surface wave).

References

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