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Oblique propagation of spatial solitons in patterned optical structures

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ABSTRACT

The propagation of waves in inhomogeneous structures is a fundamental class of problem in many physics and engineering disciplines. Much research in photonics over the past decade has considered how spatial solitons (self-collimating light beams) interact with nonlinear optical materials whose refractive-index profile has been periodically patterned [Mandelik *et al.*, Phys. Rev. Lett. vol. 92, 093904 (2004)]. This type of arrangement is subtle and highly complex: account must be taken of diffraction (linear spreading), self-focusing (from system nonlinearity), and the interplay between these two effects in the presence of host-medium periodicities.

Periodic optical structures generally fall into one of two categories that are historically regarded as being physically distinct: *coupled-waveguide arrays* and *photonic crystals*. These geometries are, in fact, equivalent and they are tightly connected with spatial symmetry. Such unification is possible only when the underlying wave equation possesses certain key mathematical properties that, to date, have been largely absent from the literature (paraxial theory, with slowly-varying envelopes and small-angle approximations, obscures such a connection). In this presentation, we propose a nonparaxial model capable of describing arbitrary-angle evolution of scalar beams in periodic systems. By retaining a governing equation that is naturally of the inhomogeneous-Helmholtz class [Sánchez-Curto *et al.*, Opt. Lett. vol. 32, 1126 (2007)], 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 patterning. Extensive simulations have revealed that oblique injection may excite of a wide range of novel angle-dependent phenomena.