Propagation properties of Helmholtz power-law nonlinear surface waves

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THEME 1: NONLINEAR DYNAMICS

APPLICATION THEME 1: PHYSICAL SCIENCES

Optical surface waves are a fundamental class of excitation in inhomogeneous nonlinear photonic systems. This type of laser light satisfies a Helmholtz-type governing equation, and is subject to certain boundary conditions. It also has an asymmetric cross-sectional shape due to abrupt changes in material properties that define the (e.g., planar) interface. The stability properties of surface-wave solution branches are notoriously difficult to predict. On the one hand, classic criteria (e.g., Vakhitov-Kolokolov) often fail; on the other hand, numerical computations have, historically, been performed only with approximated governing equations (e.g., of the Schrödinger type).

In recent research endeavours [J. M. Christian *et al.*, J. At. Mol. Opt. Phys., *in press*], we have derived the surface waves for a Helmholtz-type interface model with refractive-index profile that depend on the local light amplitude to an arbitrary power $0 < q < 4$. This generic optical nonlinearity describes classes of semiconductors, doped filter glasses, and liquid crystals.

Here, we will present the first full investigation of Helmholtz nonlinear surface waves. Exact analytical solutions will be reported, and their properties explored. Extensive simulations with the full (i.e., un-approximated) governing equation have addressed some key issues surrounding the robustness of surface-wave solutions against spontaneous instabilities. New qualitative phenomena have also been predicted when considering interactions between surface waves and (obliquely-incident) spatial solitons (that is, self-collimated laser beams). The interaction angle between the surface-wave and incoming soliton is found to play a pivotal role in determining post-collision behaviour in the system, as is the nonlinearity exponent q.