SCCS 2012

Instabilities and Helmholtz vector solitons in nonlinearly-coupled optical systems

C. Bostock, J. M. Christian, and G. S. McDonald
Materials & Physics Research Centre,
University of Salford, Greater Manchester M5 4WT, UK

KEYWORDS:

Modulational instability, vector solitons, self-focusing, mutual focusing, nonlinear materials

THEME 1: NONLINEAR DYNAMICS

APPLICATION THEME 1: PHYSICAL SCIENCES

The propagation of, and interaction between, multiple waves is a fundamental problem in physical science. The interplay between linear and nonlinear processes – such as diffraction (wave spreading) and self-/cross-phase modulation (wave compressing), respectively – can often lead to interesting and potentially exploitable phenomena. For instance, localized excitations that overlap in space may lock together to form a multi-component bound state that evolves with a stationary (unchanging) wave profile: a vector soliton.

Vector solitons are ubiquitous in photonics. In both nonlinear-pulse and nonlinear-beam contexts (here, we focus on the latter), they are routinely described by a pair of simplified coupled equations which, while straightforward to handle mathematically, lack the capability of describing a range of physically relevant effects [R. De La Fuente and A. Barthelemy, Opt. Commun. vol. 88, 547 (1992)]. One such effect that particularly interests our group is oblique propagation (waves travelling off-axis at arbitrary angles with respect to the reference direction).

We will present the first complete account of off-axis effects in a much more general two-component nonlinear optical system. New qualitative regimes of stability, that are absent from the classic (but restrictive) plane-wave analyses of other authors [G. P. Agrawal, J. Opt. Soc. Am. B vol. 6, 1072 (1990)], have been uncovered as a function of the wave-coupling strength. These predictions have profound implications for the propagation properties of vector solitons. We will also detail four novel families of exact analytical vector solitons. Robustness against perturbations to the local beam shape is tested by fully-nonlinear (i.e., numerical) computations.