Two-colour spatial optical solitons: new stability analyses for off-axis propagation

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Two-colour spatial optical solitons comprise a pair of stationary continuous-wave light beams at two well-separated temporal frequencies. The components overlap in the propagation plane and are coupled through system nonlinearity (e.g., the Kerr-type response in the host material of a planar waveguide) [Opt. Commun. **88**, 419 (1992)]. Such configurations have huge potential for future photonic device applications such as multi-channel waveguiding [Opt. Lett. **19**, 945 (1994)]. To date, analyses of such geometries have been mainly within the arena of paraxial wave optics.

Our research goes beyond the slowly-varying envelope approximation, into regimes where two-colour light fields may propagate and interact off-axis at arbitrary angles and orientations. The coupled governing equations are of the nonlinear *Helmholtz* (as opposed to *Schrödinger*) type [Phys. Rev. E **74**, 066612 (2006)]. In an essential way, this more general system involves the interplay between nonlinear (self- and cross-focusing) processes and, crucially, fully two-dimensional diffraction.

We will present the first analysis of off-axis two-colour light fields. Four families of exact analytical two-colour soliton (bright-bright and bright-dark for a focusing Kerr nonlinearity; dark-bright and dark-dark for defocusing) have been derived, each of which has co- and counter-propagation classes that are related by geometrical transformations. Solution of the plane wave modulational instability problem, obtained by generalizing our established Helmholtz linearization techniques [J. Phys. A **39**, 1535 (2006)] to vector regimes, has provided further insight into the propagation properties of those two-colour solitons with dark-type components. Unexpected regions of stability, mediated by cross-focusing, have been uncovered in certain parameter regimes.