Vector spatial solitons: off-axis nonparaxiality in coupled Helmholtz equations

C. Bostock, J. M. Christian, and G. S. McDonald

Materials & Physics Research Centre, University of Salford, U.K.

Email: c.bostock1@edu.salford.ac.uk

Keywords: spatial solitons, Helmholtz equations, modulational instability

Vector spatial solitons are complex optical beams with several distinct components. These components (which may be bright-like and/or dark-like) are localized in space and tend to overlap strongly in the propagation plane, thereby allowing the interplay between diffraction and nonlinear effects (e.g., self- and mutual-focusing) to result in stationary light structures. Our group has proposed a more complete and realistic model for describing *two-colour* vector phenomena, where each electric-field component is at a distinct optical frequency (e.g., ω_1 and ω_2). A key feature of our approach is that one may access multi-colour geometries involving beam propagation at *arbitrary angles and orientations* with respect to the reference direction *in the laboratory frame* – such considerations are central to technological device architectures involving multiplexing and interface geometries, but lie far outside the reach of conventional theory [1,2]. We have recently solved the modulational instability problem (which is 4x4 in nature) exactly [3], and extensive computations have confirmed theoretical predictions (e.g., the instability of bright-dark solitons in a focusing Kerr medium). New families of exact analytical two-colour solitons have also been derived (see figure 1), each of which has *co-propagation* and *counter-propagation* classes that are related by geometrical transformation.
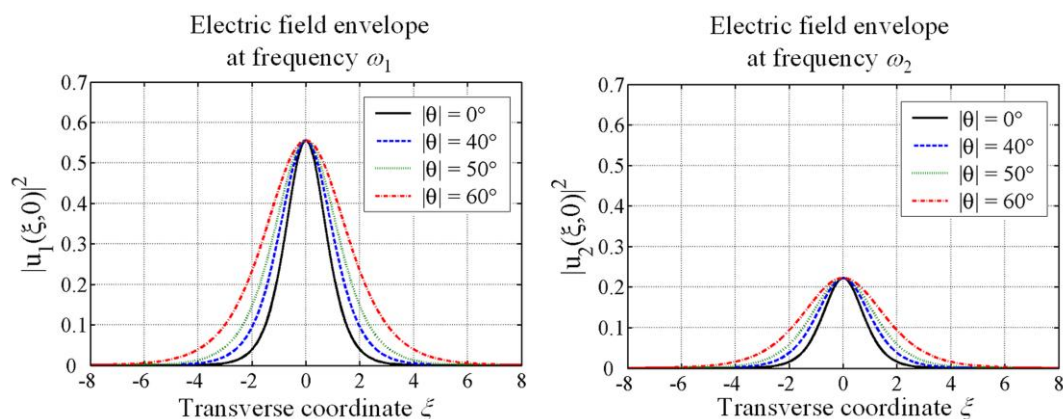

Figure 1. Intensity profiles for bright-bright two-colour Helmholtz spatial solitons travelling off-axis at angle θ.

References
[1] R. De La Fuente and A. Barthelemy, Opt. Commun. **88**, 419 (1992).
[2] M. Shalaby and A. J. Barthelemy, IEEE J. Quantum Electron. **28**, 2736 (1992).
[3] C. Bostock, MPhil thesis "Two-colour Helmholtz solitons with a defocusing Kerr nonlinearity," University of Salford (2011).