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Vector spatial solitons beyond the slowly-varying envelope approximation

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The simultaneous propagation of two spatially-overlapping and differently-coloured laser beams (e.g., at infra-red and green wavelengths) in photonic waveguides has attracted much attention since the early 1990s [Shalaby & Barthelemy, IEEE J. Quantum Electron. vol. 28, 2736 (1992)]. Historic analyses of the two-colour optical propagation problem have routinely adopted models of the nonlinear-Schrödinger class that are inherently bound by the slowly-varying envelope approximation (SVEA) [De La Fuente & Barthelemy, Opt. Commun. vol. 88, 419 (1992)]. While desirable in some respects (e.g., by considerable simplification of the governing equations), the SVEA can place some strong physical constraints on the validity of predictions made by Schrödinger-type systems in context of wave optics and the theory of nonlinear beams. Our approach avoids such limitations by dealing with the more general (i.e., un-approximated) Helmholtz-type governing equations.

In this presentation, we will deliver a concise overview of our investigations into a model of two-colour light beams beyond the SVEA. A plethora of new results will be provided, including the derivation of four exact analytical vector soliton families. A novel linearization technique, which generalizes conventional methods [Agrawal, J. Opt. Soc. Am. B vol. 6, 1072 (1990)] to capture the Helmholtz type of governing equation, is also developed to assess the resilience of the system against the emergence of spontaneous instabilities. Theoretical calculations are supported by fully-nonlinear computer simulations. We expect our results to play a key role in the design of future photonic devices that incorporate angular nonparaxial-beam configurations into their two-colour operational architecture and geometry.