Spatiotemporal dark and anti-dark solitons in cubic-quintic photonic systems

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In a recent publication, Christian *et al.* [Phys. Rev. Lett. vol. 108, art. no. 034101 (2012)] developed a novel mathematical formalism for describing pulses in generic wave-based systems. When applied to optical geometries, their proposed class of (Helmholtz-type) governing equation captures the interplay between cubic nonlinearity, temporal dispersion, and spatial dispersion. The last effect cannot be described within conventional frameworks because of the inherent assumptions made in those (Schrödinger-type) models. Historically, such a limitation has tended not to matter since spatial dispersion could often be safely neglected. However, there exist modern photonic contexts [e.g., Biancalana and Creatore, Opt. Exp. vol. 16, 14882 (2004)] where spatial dispersion must be accommodated.

In this presentation, we will report on our latest research into the theory of optical pulse propagation and related nonlinear phenomena. This work has broad application in the design of future photonic device architectures, where light pulses (e.g., produced by a laser and injected into a waveguide) can be used as 'bits' of optical information. New results for cubic-quintic nonlinearity include calculations of wave instabilities and the derivation of exact analytical dark-soliton pulses. We have also taken the first steps toward understanding the anti-dark class of solution. Non-trivial corrections to the predictions of conventional pulse theory (e.g., how pulse speeds depend upon system parameters) have been identified, and through asymptotic methods we have recovered classic results [Herrmann, Opt. Commun. vol. 91, 337 (1992)] in the limit of negligible spatial dispersion. Compelling evidence of pulse stability has been obtained through extensive simulations.