Dark & anti-dark spatiotemporal solitons: from cubic to cubic-quintic systems

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The origin of conventional models for optical pulse propagation lies in the universal slowly-varying envelope approximation (SVEA) accompanied by a Galilean boost to the local time frame. However, Biancalana and Creatore [1] have recently pointed out that the SVEA is not necessarily compatible with physical contexts involving spatial dispersion [2]. Their proposal has prompted us to reassess the way in which conventional pulse theory handles the linear part of the wave operator. In so-doing, we have constructed a framework for scalar optical pulses that is based upon transformation laws and frame-of-reference considerations [3]. Here, we present our most recent research analysing soliton propagation in systems with the universal cubic-quintic type of nonlinearity [4]. By deploying a range of analytical methods, we have been able to derive exact spatiotemporal dark and anti-dark solitons. These structures have a strongly geometrical flavour that is tightly connected to the symmetry properties of the governing equation. Multi-parameter asymptotic analyses demonstrate that classic conventional solitons are a subset of our new solutions. Extensive numerical calculations have also predicted a high degree of robustness of bright and dark pulses [see Figs. 1(a) and 1(b), respectively] against local perturbations to their temporal shape.

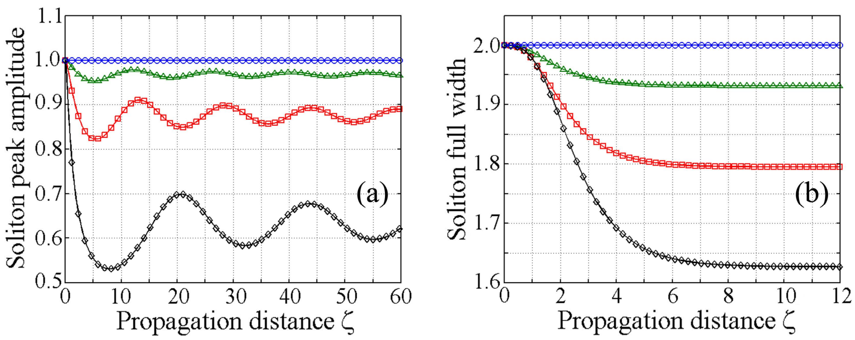

Figure 1. Simulations showing the stability of perturbed (a) bright (anomalous temporal dispersion) and (b) dark (normal temporal dispersion) spatiotemporal solitons. Blue (circle): unperturbed solution, where the pulse evolves with a stationary shape. Green (triangle), red (square) and black (diamond) curves: increasing perturbation, respectively.

References

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