Helmholtz dark solitons: oblique propagation, saturable materials & bistability

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Dark spatial optical solitons comprise a uniform background wave that is modulated by an obliquely-propagating 'dip' in the light intensity profile. Appearing throughout nonlinear science, these universal entities possess a phase topology that endows them with a remarkable degree of stability against perturbations to their shape. Hence, the photonics community is greatly interested in dark solitons for potential use as 'information bits' in future optical technologies. Our Group has been developing Helmholtz soliton theory for the past 14 years. This more sophisticated modelling approach completely eliminates the intrinsic angular limitations of classic paraxial models, where waves must travel along (or at near-negligibly-small angles with respect to) the laboratory longitudinal direction. The most recent system we have analyzed captures the generic effects of a saturable defocusing nonlinearity, where the locally-induced refractive-index change becomes bleached under high-intensity illumination. Families of exact bistable dark solitons have been derived by deploying a unique blend of mathematical methods (see figure 1), and linearization techniques have predicted the inherent stability of the background plane wave against small-amplitude modulations. Our new solutions have a raft of crucial asymptotic properties, complementing their bright [1] and paraxial [2] counterparts.

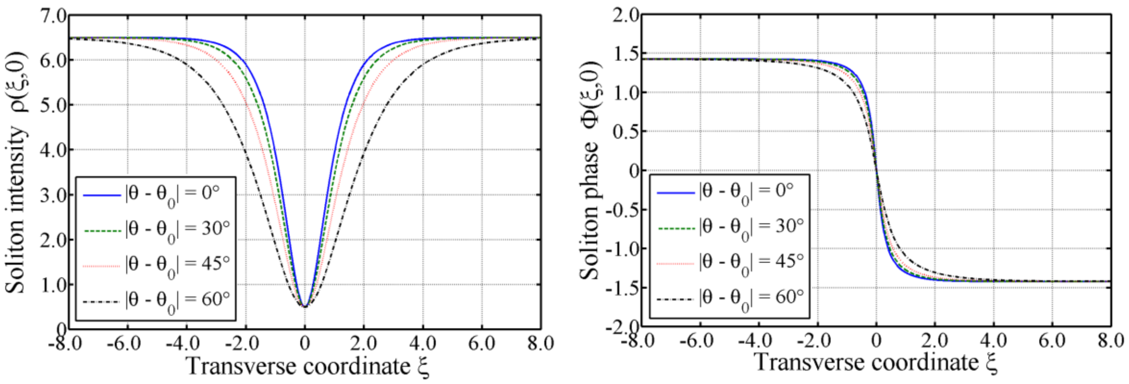

Figure 1. Intensity (left) and phase (right) quadratures of an exact Helmholtz dark soliton for a saturable defocusing nonlinearity as the net propagation angle in the laboratory frame (denoted by $\theta - \theta_0$) is increased.

References

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[2] W. Krolikowski and B. Luther-Davies, Opt. Lett. **18**, 188 (1993).