Coupled spatiotemporal waves: new paradigms in vector soliton physics

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Keywords: vector solitons, spatiotemporal dispersion, *energy theme*

In this presentation, we propose a novel spatiotemporal generalization of Menyuk's classic equations [1] describing the propagation of two nonlinearly-coupled waves in a dispersive optical system (such as a fibre or planar waveguide). Our approach is similar in spirit to that recently introduced by Christian *et al.* [2] in a single-component context: both analyses are firmly rooted in special relativity-inspired frame-of-reference considerations, and are concerned with the universal properties of waves in fully second-order systems (where evolution is allowed to venture beyond the realms of the ubiquitous slowly-varying envelope approximation). Research highlights include the complete solution of the modulational instability (MI) problem for vectorized spatiotemporal continuous-wave solutions (the characteristic equation turns out to be an eighth-degree polynomial, rather than a quartic [1]). Predictions of the most-unstable frequency in the system, obtained from consultation of the MI spectrum, are in full agreement with extensive numerical calculations [see Figs. 1(a) & 1(b)]. We have also derived exact bright-bright solitons and investigated some of their key characteristics (e.g., robustness and the asymptotic recovery of Menyuk-type solutions). Future work will address spatiotemporal vector dark solitons [3,4] [see Fig. 1(c)].

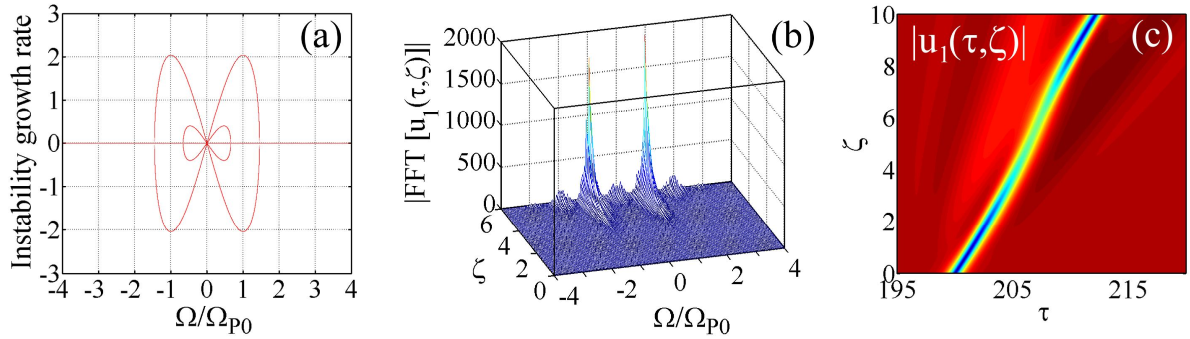

Figure 1. (a) Typical long-wave MI spectrum when both waves experience anomalous temporal dispersion. (b) Extensive simulations have confirmed the prediction for the most-unstable frequency, denoted by Ω_{P0} [related to the dominant peak in part (a)]. (c) Instability of a conventional dark-dark type of initial condition used for the spatiotemporal governing equation.

References

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