Rogue waves: rational solitons and wave turbulence theory

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Abstract:

Solitons on finite background (SFB) and particularly rational solitons (RS) are exact analytical solutions of integrable wave equations, and for this reason they may be regarded as a coherent and deterministic approach to the understanding of rogue wave (RW) phenomena. However, RWs events are known to spontaneously emerge from an incoherent turbulent state of the system. It is thus of fundamental importance to study whether RSs can emerge from a turbulent environment (i.e., in more realistic oceanic conditions). To this aim, we first review here our recent experiments based on optical fiber systems to generate the localized nonlinear structures evolving upon a nonzero background plane wave (the Akhmediev, Peregrine and Kuznetsov-Ma solutions) [1-2]. The setup is based exclusively on commercially available telecommunication-ready components and standard silica fiber. It allows us to observe a complete family of SFB solutions to the nonlinear Schrodinger equation. Next we show how a suitably low frequency modulation on a continuous wave can induce higher-order modulation instability splitting. This phenomenon arises from the nonlinear superposition of single breather evolutions [3]. Finally we study the emergence of rogue waves and RSs in a genuine turbulent wave system. In particular we show that the coherent deterministic description of RWs provided by the rational soliton solutions is compatible with an accurate statistical description of the random wave provided by the wave turbulence theory. Furthermore, the simulations reveal that even in the weakly nonlinear regime, the nonlinearity can play a key role in the emergence of an individual rogue wave event in a turbulent environment [4].

References:

1. B. Kibler *et al.*, Nature Phys. 6, 790 (2010).
2. B. Kibler *et al.*, Sci. Reports 2, 463 (2012).
3. M. Erkintalo *et al.*, Phys. Rev. Lett. 107, 253901 (2011).
4. B. Kibler *et al.*, Phys. Lett. A 375, 3149 (2011).