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JONSWAP rogue waves over a non-uniform background

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Rogue waves in random sea states modeled by the JONSWAP power spectrum are high amplitude waves arising over non-uniform backgrounds that cannot be viewed as small amplitude modulations of Stokes waves. In the context of Nonlinear Schrödinger (NLS) models for waves in deep water, this poses the challenge of identifying appropriate analytical solutions for JONSWAP rogue waves, investigating possible mechanisms for their formation, and examining the validity of the NLS models in these more realistic settings. In this talk we investigate JONSWAP rogue waves using the inverse spectral theory of the periodic NLS equation for moderate values of the period. For typical JONSWAP initial data, numerical experiments show that the developing sea state is well approximated by the first few dominant modes of the nonlinear spectrum and can be described in terms of a 2- or 3-phase periodic NLS solution. As for the case of uniform backgrounds, proximity to instabilities of the underlying 2-phase solution appears to be the main predictor of rogue wave occurrence, suggesting that the modulational instability of 2-phase solutions of the NLS is a main mechanism for rogue wave formation and that heteroclinic orbits of unstable 2-phase solutions are plausible models of JONSWAP rogue waves [1]. To support this claim, we correlate the maximum wave strength as well as the higher statistical moments with elements of the nonlinear spectrum. The result is a diagnostic tool widely applicable to both model or field data for predicting the likelihood of rogue waves. Finally, we examine the validity of NLS models for JONSWAP data, and show that NLS solutions with JONSWAP initial data are described by non-Gaussian statistics, in agreement with the TOPEX field studies of sea surface height variability.

[1] Characterizing JONSWAP rogue waves and their statistics via inverse spectral data, A. Calini and C.M. Schober, Wave Motion, 2016.
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