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A Mel'nikov and inverse spectral analysis of rogue waves in deep water

Rogue waves in deep water are investigated in the framework of the nonlinear Schrödinger (NLS) and the modified Dysthe (MD) equations. We observe that a chaotic regime greatly increases the likelihood of rogue wave formation. Enhanced focusing is shown to occur due to chaotically generated optimal phase modulations. A Melnikov analysis indicates persistence of a homoclinic solution in the MD system which is $O(\varepsilon)$—close to an optimally phase modulated solution of the NLS. The correlation of the Mel'nikov analysis and the numerical experiments indicates that one approach to predicting rogue waves in realistic oceanic states is to determine the proximity of a sea state to homoclinic data of the NLS. Using the inverse spectral theory of the NLS equation, we show that the development of extreme waves in random oceanic sea states characterized by JONSWAP power spectra is well predicted by the proximity to homoclinic data of the NLS.

Abstract of talk given at ICMS Workshop on Rogue Waves December 2005.
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