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Wind and viscosity effects on ocean waves: analytical and numerical approaches

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The nonlinear Schrödinger equation (NLS) is the simplest model describing the evolution of deep-water gravity waves: beside a good prediction of the existence and propagation of breathers and solitons, it describes well the average properties of statistically-stationary random sea-states. Under the action of external forcing (like wind and dissipation due to wave breaking or viscous damping), the NLS is no more sufficient and needs to be modified by introducing additional terms to model broader spectra [1], homogeneous gain/loss or inhomogeneous corrections [2-3].

We will show that a simple analytical model can still be recovered from the full model by considering a low-dimensional three-wave truncation [4-5] that allows us to describe the nonlinear behaviour of modulation instability under different wind forcing strengths. It turns out that the evolution of the norm and of the spectral mean in the full model are well captured by the reduced three-wave dynamics. Different regimes are found for the wind-viscosity balance: we classify them according to the attractor in the phase-plane of the truncated system and to the shift of the spectral mean.

We will also discuss the impact of dispersive forcing/damping on a random sea-state, by means of a numerical analysis of the probability distribution function of wave amplitudes. The dynamical behaviour of the Benjamin-Feir index (which relates to the onset of modulation instability of incoherent waves) and kurtosis, *i.e.* the deviation from Gaussianity which quantifies the probability of extreme events, is shown to change according to the relative weight of damping and forcing.

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