# On non-linear changes to the shape of extreme wave-groups in deep water

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In this abstract we examine the non-linear changes caused by wave-wave interactions to large waves on deep water using numerical simulations. We use simulations of random linear directionally spread waves to generate our initial conditions. From these linear simulations we extract the sea-surface around a number of large wave events. We run these back in time under linear evolution before running them forward using the broad-banded non-linear Schrodinger equation [1]. We compare the wave-groups in the linear and non-linear cases. A typical result showing the envelope in linear and non-linear cases is shown in the figure. Methods and results are described in detail in [2].

We find that, on average, we only get extra elevation above that expected under linear evolution for low directional spreads. Real ocean waves are directionally spread and it is unlikely that the spectra for which we do see extra amplification would occur in the open ocean. However, for more realistic initial conditions some waves are magnified which may be a concern for offshore engineering design.

Non-linearity can cause a significant change to the aspect ratio of an extreme wave-group, with the group contracting in the mean wave-direction and expanding laterally. However, these are not coupled. The lateral expansion of the wave-group occurs even in relatively mild seas. However, the mean wave direction contraction occurs only for steep sea-states with low directional spreads.

The final non-linear change is that the largest wave within a wave-group will tend to move to the front of the group. This means that for an Eulerian observer in the ocean the wave preceding an extreme wave will usually be relatively small. This effect occurs most dramatically in steep sea-states with low directional spreading.

References

[1] Trulsen, Karsten, and Kristian B. Dysthe. "A modified nonlinear Schrödinger equation for broader bandwidth gravity waves on deep water." *Wave motion* 24.3 (1996): 281-289.

[2] Adcock, Thomas AA, Paul H. Taylor, and Scott Draper. "Nonlinear dynamics of wave-groups in random seas: unexpected walls of water in the open ocean." *Proc. R. Soc. A*. Vol. 471. No. 2184..