Distribution of extreme waves by simulations.

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Abstract

Several ideas for physical mechanisms that can produce large waves have been suggested as reasons for rogue- or freak waves (see e.g. Dysthe 2000, Kharif & Pelinovsky 2004). It seems, however, that these mechanisms need special preparations or coherence to work. It is therefore difficult to see how they can occur spontaneously during a storm on the open ocean.

To investigate the possibility that nonlinear wave interactions may influence the spontaneous occurrence of extreme waves, we have done fairly large scale 3D simulations using higher order NLS type equations (Dysthe 1979). Our "numerical" ocean contains approximately 10^4 waves at any time, and has a time horizon of 150 typical wave periods $2\pi/\omega_p$. As has been reported elsewhere (Dysthe et.al. 2003) a characteristic evolution is seen where the initial wave spectrum "relaxes" towards a more steady form. This process is most prominent for very narrow spectra, and takes place on the Benjamin Feir timescale $(\omega_p s^2)^{-1}$ where s is a typical steepness. Such spectral change due to the Benjamin-Feir type instability has been linked to increased occurrence of extreme waves (Onorato et.al. 2000, Mori & Yasuda 2000, Janssen 2003). This connection is investigated using our simulations.

We are concerned with the distributions of surface elevation and crest height. For relatively short crested waves the mentioned spectral evolution does not seem to influence these distributions significantly. We find that up to 5 standard deviations the theoretical distributions found by Tayfun (1980) seems to fit the simulated data very well. For a very narrow initial angular distribution, however, we see a significant increase in the occurrence of extreme waves during the spectral relaxation, in qualitative agreement with laboratory experiments done by Onorato et.al. (2004).

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