Abstract View

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Nonlinear Contributions to the Frequency Spectrum of Wind-Generated Water Waves

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ABSTRACT

In the continuous frequency spectrum of wind-generated water waves Fourier components have different origins. At a particular frequency, some will be harmonies resulting from the nonlinear profiles of lower frequency waves, others will be near-free gravity waves. In this paper the relative importance of these two different contributions is studied in the case that the nonlinearities can be treated perturbatively. The calculation starts from a fit to observed spectra: in the sea the JONSWAP spectrum is chosen; in the laboratory a different fit with a sharper fall-off near the spectral peak is taken. The nonlinear corrections are most significant at frequencies larger than twice the peak frequency and increase with increasing frequency. They are determined mainly by the behavior of the spectrum near the peak. The relative importance of the nonlinear contributions increases with decreasing dimensionless fetch. This is in agreement with experimental observations. In the laboratory, with narrower spectra, nearly all of the spectral energy at twice the peak frequency is due to the nonlinear contributions. The observed magnitude agrees reasonably well with our calculated value. In the open-ocean nonlinear corrections are a small fraction of the linear contribution at this frequency. For a nonlinear system the concept of phase velocity loses its meaning in general. Nevertheless, experimentally, nonlinearities will show up as an anomaly in the observed phase velocity. This anomaly is studied. In the laboratory, where the nonlinearities dominate, a large anomaly is expected and this agrees with the observations. In the open sea experimental evidence is conflicting. It is found that several mechanisms tend to suppress the anomaly, so that small deviations from the linear value are obtained.