Shrira, Victor

Rogue waves on currents with vertical shear

There is a vast anecdotal evidence suggesting that rogue waves are much more frequent in areas of the ocean characterised by the presence of strong currents with vertical shear. Perhaps, the best known are those associated with ill famed Aguilhas current, off the coast of South-East Africa. However, so far no studies have targeted the specific nonlinear mechanisms responsible for the freak wave formation on such currents. The present paper is aimed at this gap.

An asymptotic model describing evolution of a weakly nonlinear wave packet on a current with vertical shear is developed. The small parameters are the smallness of the wave steepness (weak nonlinearity), narrowness of wave spectra, and smallness of current velocity compared to the phase velocity of water waves under consideration. It is shown that the transverse instability of plane waves due to interaction with current is much stronger than the classical Benjamin-Feir instability. The model describes how wave packets propagating against the current create self-induced waveguides, similar to waveguides caused by self-focussing in nonlinear optics and plasmas. There is a number of mechanisms leading to narrowing, or even to collapse of these waveguides, and, thus, to sharp growth of the wave amplitude.

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