

Nonlinear wave focusing as a mechanism of the freak wave generation in the ocean

Efim Pelinovsky¹⁾ and Christian Kharif²⁾

¹⁾Laboratory of Hydrophysics and Nonlinear Acoustics, Institute of Applied Physics, 46 Ulianov Str., 603600 Nizhny Novgorod, Russia, enpeli@hydro.appl.sci-nnov.ru,

²⁾Institut de Recherche sur les Phénomènes Hors Equilibre, Parc Scientifique et Technologique de Luminy, 13288 Marseille, Cedex 9, France, kharif@pollux.univ-mrs.fr.

Abstract for Rogue waves 2000 workshop, Brest, 29 - 30 November

The freak wave appearance is a phenomenon observed in many areas of the World Ocean. Several physical mechanisms of the freak wave phenomenon are discussed. First of all, the water wave interaction with opposite current is considered as mechanism of wave amplification due to the blocking of water wave on current. The second mechanism of wave amplification is related with the formation of caustics in the wave field on the random current. These theories are applied to explain the freak wave formation in the Agulhas current off the south-east coast of South Africa. Many observations of abnormal waves had been done in the areas with no strong currents. For such areas the mechanism of wave focusing related with the dispersion enhancement has been studied analytically in the framework of the linear theory and in the laboratory tank. Recently, it was shown that the effect of modulation instability (Benjamin – Feir instability) of nonlinear water waves in deep water can produce giant waves, and the opinion that this mechanism becomes very popular.

In our opinion, the mechanism of the focusing of nonlinear water wave packets related with the phase (frequency) modulation should play significant role in the "short-lived" freak wave formation for both, deep and shallow water. This mechanism may be realized for specific meteorological conditions. For instance, the increase of wind speed results that wave packets with large group velocities are generated later than wave packets with lower group velocities, and due to process of propagation the impulse of very large amplitude can be formed by the superposition of many spectral packets. Significant wave focusing in laboratory tank was reported in several papers for the wide variation of the ratio of wavelength/depth. In our paper analytical solutions, demonstrating this linear focusing mechanism, will be given. It will be shown also that the mechanism of wave focusing is "working" in the nonlinear theory of shallow water. The method to find possible forms of the wave trains evolved into the freak wave, including random background of wind waves will be suggested. Because of absence of the Benjamin - Feir instability for shallow water, the "focusing" mechanism seems to be major in shallow water. For deep water the mechanism of freak wave formation due to focusing of the nonlinear wave packets with the phase modulation will be compared with the possible generation of giant waves due to the "usual" Benjamin - Feir instability of water waves. Main result here is that the frequency modulation of a nonlinear wave field leads to the greatest amplification of the freak wave than the amplitude modulation usually studied in the theory of the Benjamin - Feir instability. Numerical simulations of the several evolution equations (Korteweg – de Vries equation, nonlinear Schrodinger equation) demonstrate the details of the freak wave formation from deterministic and random wave field. Particularly, these results are published in:

Pelinovsky E, Kharif C. Simplified model of the freak wave formation from the random wave field. *Proc. 15th Int. Workshop on Water Waves and Floating Bodies*, Israel, 2000, 142-145.

Pelinovsky E., Talipova T., Kharif C. Nonlinear dispersive mechanism of the freak wave formation in shallow water. *Physica D*, 2000, v. 147, N. 1-2, 83-94.