Wave spectrum evolution due to 4-wave non-linear interactions evaluated with the quasi-exact Gaussian Quadrature Method

Alessandro Guerri[1,2], Michel Benoit[1,2], Maria Teles[1], Thierry Fouquet[1]

[1] Laboratoire National d'Hydraulique et Environnement (LNHE), EDF R&D, 6 quai Watier, 78401 Chatou
[2] LHSV - Laboratoire d'Hydraulique Saint-Venant, ENPC, Institut Polytechnique de Paris, EDF R&D, 6 quai Watier, 78401 Chatou

alessandro.guerri@edf.fr

In oceanic domains, the dominant wave-wave interactions occur at third order of non-linearity and are resonant [4]. The transfers take place within quadruplets of wave components satisfying two resonance conditions, on wave number vectors and frequencies. However, the exact calculation of this transfer term is very demanding and requires significant computing resources, so that operational third-generation (3G) wave models still use approximations of the full equation. The Discrete Interaction Approximation (DIA) method is the algorithm most often used, but it represents a crude approximation. Based on an approach proposed by Lavrenov [3], an efficient quasi-exact method using Gaussian Quadratures (GQM) was developed by Benoit, Gagnaire-Renou et al. [2], and then implemented in the TOMAWAC 3G model. In the present work, we solve Hasselmann's kinetic equation with GQM to study the time evolution of the wave spectrum in deep water. We consider the case of a homogeneous sea-state evolving under the effect of four-wave interactions solely (starting from arbitrary spectral shape). We examine the formation of an equilibrium shape of the spectrum, in particular for the high-frequency tail where a decay in f^{-4} is obtained. These simulation results are compared with results from the weak turbulence theory [1]. In particular, we show that the spectrum dynamics is strongly self-similar, after an initial transient phase, as shown in Fig. 1. It is also observed that, regardless of the initial condition, the spectrum seems to converge to the same shape in the long time.

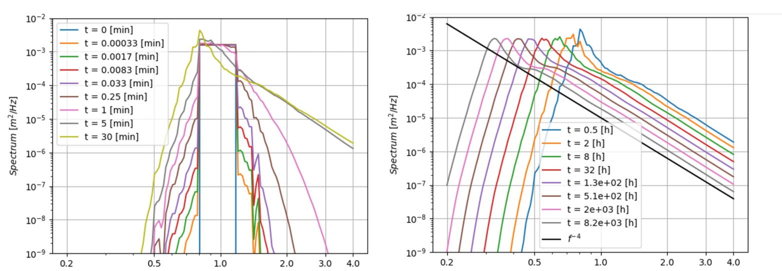

Figure 1. Evolution of the frequency spectrum under 4-waves interaction effects. After a short-term phase (left) the spectrum assumes a self-similar behaviour in the long time (right).

References

1. S.I. Badulin & al, Self-similarity of wind-driven seas *Nonlinear Proc. in Geoph.*, **12**, 891-945 (2005).
2. E. Gagnaire-Renou & M. Benoit & P. Forget, Ocean wave spectrum properties as derived from quasi-exact computations of nonlinear wave-wave interactions *Journal of Geophysical Research C (Oceans)*, **115(C12)**, (2010).
3. I.V. Lavrenov, Effect of wind wave parameter fluctuation on the nonlinear spectrum evolution *J. Phys. Oceanogr.*, **31**, 861-873 (2001).
4. K. Hasselmann, On the non-linear energy transfer in a gravity-wave spectrum. Part I: General theory *Journal of Fluid Mechanics*, **12**, 481-500 (1962).