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► **To cite this version:**

Efim Pelinovsky, Ira Didenkulova, Ana Sergeeva. Wave turbulence in shallow water. CFM 2009 - 19ème Congrès Français de Mécanique, Aug 2009, Marseille, France. <hal-03378269>

**HAL Id: hal-03378269**

**<https://hal.science/hal-03378269v1>**

Submitted on 14 Oct 2021

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# Wave turbulence in shallow water

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## Abstract

Nonlinear random wave interaction in shallow water is studied. To compare with deep water, the dispersion in shallow water is weak and the correlation between spectral components is strong. It leads to soliton formation in random wave field. The wave random dynamics within KdV equation is analyzed numerically. The soliton propagation in random media is studied analytically. The transformation of the distribution function in the process of the wave run up on a beach is investigated.

Wave turbulence in the basin of a variable depth is studied in frames of the shallow water theory. We consider an ideal fluid with a linearly varied depth,  $h(x) = -\alpha x$ , where  $h(x)$  is an unperturbed water depth,  $x$  is offshore coordinate, and  $\alpha$  is a bottom slope. The boundary-value problem is solved analytically for nonlinear hyperbolic shallow - water system. The random wave field is assumed to be a Gaussian stationary process far offshore, and it can be described by the linear theory. The wave field in the vicinity of the shoreline is a nonlinear non-Gaussian process and its statistical characteristics are calculated.

The analytical theory of the long wave runup on a plane beach is well developed for deterministic waves. It was extended on the runup of irregular waves [1]. In particular, the time evolution of the moving shoreline is described by

$$u(t) = U(t + Br \cdot u), \quad (1)$$

$$r(t) = R(t + Br \cdot u) - Br \frac{u^2(t)}{2}, \quad (2)$$

where  $r(t)$  and  $u(t)$  are dimensionless vertical displacement and velocity of the moving shoreline,  $R(t)$  and  $U(t)$  are vertical displacement and velocity at the point  $x=0$ , computed in the framework of the linear shallow water theory, and  $Br$  is a breaking parameter [1]. The variables are normalized on the significant wave height and significant wave velocity respectively.

Functions  $R(t)$  and  $U(t)$  are random Gaussian processes which can be easily found through wave characteristics offshore. Briefly, obtained results can be summarized as follows

1. Statistical moments of the velocity of the moving shoreline in the nonlinear shallow-water theory coincide with those in the linear theory

$$\langle u^n \rangle = \langle U^n \rangle. \quad (3)$$

2. Statistical moments of the vertical displacement of the moving shoreline differ from those in the linear theory prediction

$$\langle r \rangle = \frac{Br}{2} \langle U^2 \rangle, \quad (4)$$

$$\langle r^2 \rangle = \langle R^2 \rangle - \frac{Br^2}{12} \langle U^4 \rangle, \quad (5)$$

and so on.

Since the wave field in the coastal zone is nonlinear, the vertical displacement of the moving shoreline is a non-Gaussian process.

Computed distribution functions of the runup characteristics are discussed.

## References

[1] Didenkulova I., Pelinovsky E., Sergeeva A., Runup of long irregular waves on a plane beach, *In book: Extreme Ocean Waves*, 83-94, 2008.