Methods review

https://link.springer.com/content/pdf/10.1007%2F978-1-4020-8314-3.pdf

V.E. Zakharov "Freak Waves: Peculiarities of Numerical Simulations"

Slowly modulated weakly nonlinear Stokes wave is described by nonlinearShr¨odinger equation (NLSE).
The most direct way to prove validity of the outlined above scenario (NLSE) for freakwave formation is a direct numerical solution of Euler equation, describing poten-tial oscillations of ideal fluid with a free surface in a gravitational field. This solutioncan be made by the methods published in several well-known articles (Dommermuthand Yue (1987); West et al. (1987); Clamond and Grue (2001)). Here we use another method, based on conformal mapping.
More recent papers:
Shamin http://conf.nsc.ru/files/conferences/niknik-90/fulltext/35516/47103/shamin.pdf

Моделирование волн-убийц: обнаружение, предсказание и разрушение*

Р.В. Шамин
Институт океанологии им. П.П.Ширшова РАН; Новосибирский государственный университет
e-mail: roman@shamin.ru

Рассматриваются вычислительные эксперименты по моделированию поверхностных волн идеальной жидкости экстремальной амплитуды, так называемых волн-убийц. Вычисления основаны на дифференциальных уравнениях в конформных переменных. Рассматриваются такие задачи, как обнаружение и предсказание волн-убийц, а также вопросы разрушения волн-убийц в момент их возникновения.

Presentation: http://conf.nsc.ru/files/conferences/niknik-90/presentation/35516/75595/shamin.pdf

A. Toffoli "Non-Gaussian Properties of Shallow Water Waves in Crossing Seas"

Based on Korteweg–de Vries equation.

Abstract The Kadomtsev–Petviashvili equation, an extension of the Korteweg–de Vries equation in two horizontal dimensions, is here used to study the statistical properties of random shallow water waves in constant depth for crossing sea states. Numerical simulations indicate that the interaction of two crossing wave trains generates steep and high amplitude peaks, thus enhancing the deviation of the surface elevation from the Gaussian statistics. The analysis of the skewness and the kurtosis shows that the statistical properties depend on the angle between the two wave trains.

T. Talipova Modelling of Rogue Wave Shapes in Shallow water

The dynamics of non-linear long surface water waves on constant depth may be described by the Korteweg-de Vries equation (Dingemans 1996)

$$\frac{\partial \eta}{\partial t} + c\left(1 + \frac{3\eta}{2h}\right)\frac{\partial \eta}{\partial x} + \frac{ch^2}{6}\frac{\partial^3 \eta}{\partial x^3} = 0, \tag{1}$$

where η is the water surface elevation, h is the undisturbed water depth, $c = \sqrt{gh}$ is the linear speed of long surface wave and g is the gravity acceleration. Equation (1) may be reduced to dimensionless form (3) by the following transformations (2):

$$\zeta = \frac{\eta}{h}, \quad \tau = \frac{c}{h}t, \quad y = \frac{x - ct}{h}, \tag{2}$$

$$\frac{\partial \zeta}{\partial \tau} + \frac{3}{2}\zeta\frac{\partial \zeta}{\partial y} + \frac{1}{6}\frac{\partial^3 \zeta}{\partial y^3} = 0. \tag{3}$$

Review of equations to model ocean waves

https://link.springer.com/content/pdf/10.1007%2F978-0-387-30440-3_586.pdf

Other articles

Laplace equation → canonical variables

http://zakharov75.itp.ac.ru/static/local/zve75/zakharov/1968/1968-03-art3A10.10072FBF00913182.pdf

STABILITY OF PERIODIC WAVES OF FINITE AMPLITUDE ON THE SURFACE OF A DEEP FLUID

V. E. Zakharov

Zhurnal Prikladnoi Mekhaniki i Tekhnicheskoi Fiziki, Vol. 9, No. 2, pp. 86–94, 1968

ABSTRACT: We study the stability of steady nonlinear waves on the surface of an infinitely deep fluid [1, 2]. In section 1, the equations of hydrodynamics for an ideal fluid with a free surface are transformed to canonical variables: the shape of the surface $\eta(\mathbf{r}, t)$ and the hydrodynamic potential $\Psi(\mathbf{r}, t)$ at the surface are expressed in terms of these variables. By introducing canonical variables, we can consider the problem of the stability of surface waves as part of the more general problem of nonlinear waves in media with dispersion [3, 4]. The results of the rest of the paper are also easily applicable to the general case.

The first term in t
second and third term
and the potential ener
tity $\Psi(\mathbf{r}, t) = \Phi(z, \mathbf{r}, t)|$
defines the fluid flow
equation has a unique

we obtain

NLSE + Fourier with Chaotic profile:
https://arxiv.org/pdf/1512.03584.pdf

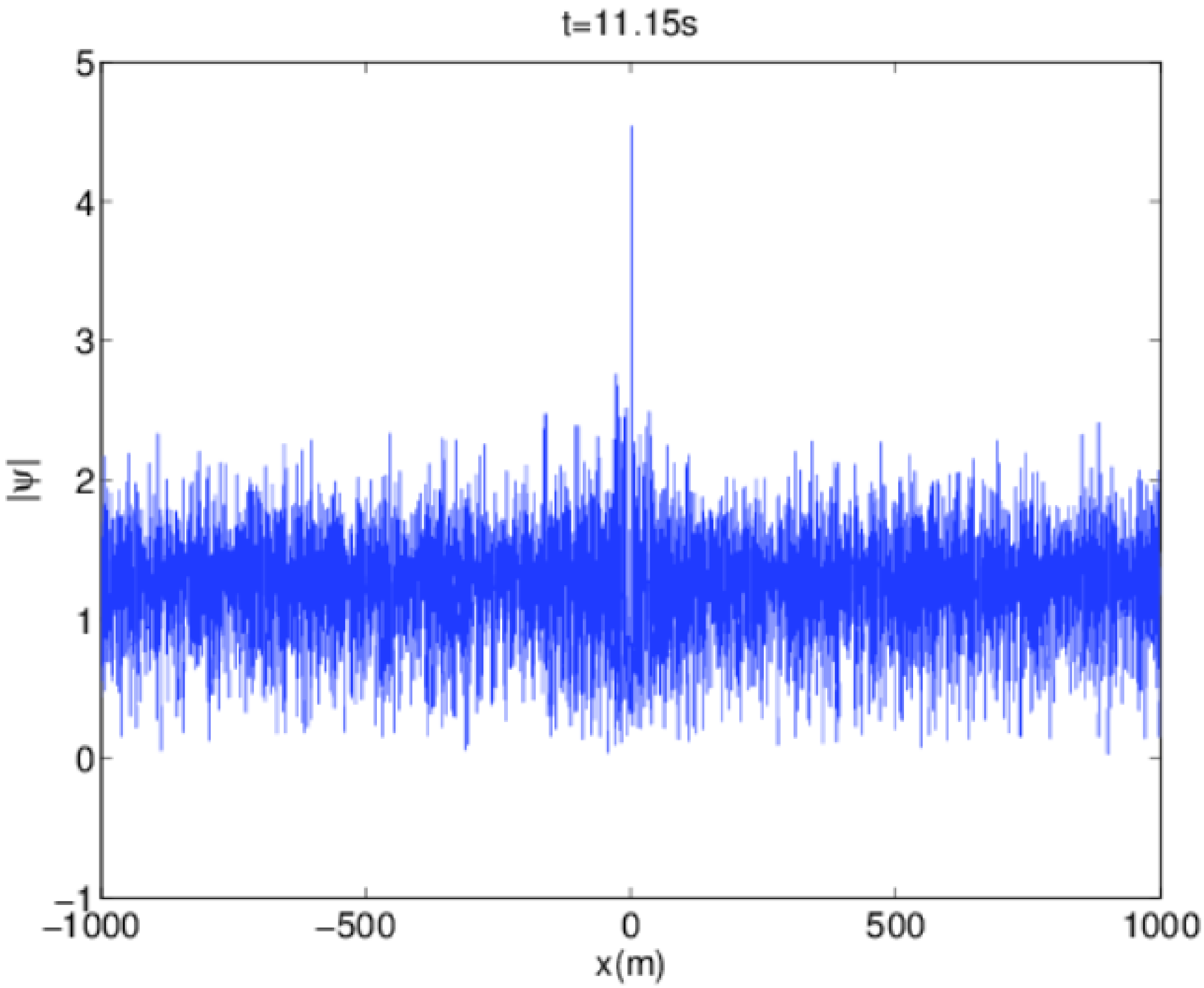
Shapes and Statistics of the Rogue Waves Generated by Chaotic Ocean Current*

Cihan Bayındır[1,†]

[1]*Department of Civil Engineering, Işık University, İstanbul, Turkey*

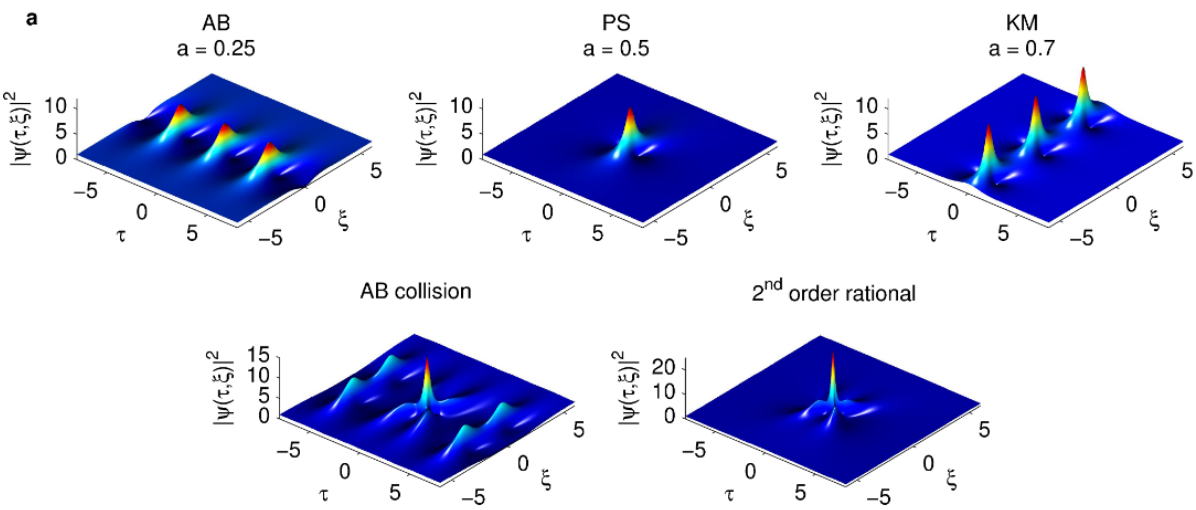
In this study we discuss the shapes and statistics of the rogue (freak) waves emerging due to wave-current interactions. With this purpose, we use a simple governing equation which is a nonlinear Schrödinger equation (NLSE) extended by R. Smith (1976). This extended NLSE accounts for the effects of current gradient on the nonlinear dynamics of the ocean surface near blocking point. Using a split-step scheme we show that the extended NLSE of Smith is unstable against random chaotic perturbation in the current profile. Therefore the monochromatic wave field with unit amplitude turns into a chaotic sea state with many peaks. By comparing the numerical and analytical results, we show that rogue waves due to perturbations in the current profile are in the form of rational rogue wave solutions of the NLSE. We also discuss the effects of magnitude of the chaotic current profile perturbations on the statistics of the rogue wave generation at the ocean surface. The extension term in Smith's extended NLSE causes phase shifts and it does not change the total energy level of the wave field. Using the methodology adopted in this work, the dynamics of rogue wave occurrence on the ocean surface due to blocking effect of currents can be studied. This enhances the safety of the offshore operations and ocean travel.

$$\psi(x,t_0+\Delta t) = F^{-1}\left[e^{-ik^2\Delta t/2}F[e^{i\left(|\psi_0|^2-x|dU/dx|\right)\Delta t}\ \psi_0]\right] \tag{18}$$



NLSE + Optics: https://arxiv.org/pdf/1410.3071.pdf

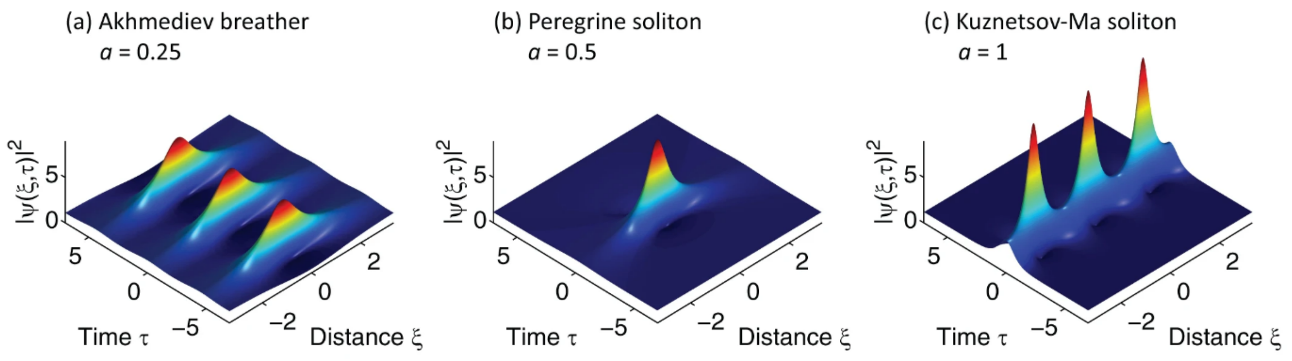
$$\psi(\xi,\tau) = e^{i\xi}\left[1 + \frac{2(1-2a)\cosh(b\xi) + ib\sinh(b\xi)}{\sqrt{2a}\cos(\omega\tau) - \cosh(b\xi)}\right]$$



Similar solutions review: https://arxiv.org/pdf/2009.00269.pdf

Figure 1

From: Observation of Kuznetsov-Ma soliton dynamics in optical fibre



Analytic solutions of the NLSE from Eq. (2) with different values of parameter a as indicated illustrating the three different classes of primary soliton on finite background solutions of the NLSE.

Back to article page ›

KdV + NLSE with comparison http://www.ifremer.fr/web-com/molagnon/bv/pelinovsky_010124_w.pdf

Nonlinear Wave Focusing as a Mechanism of the Freak Wave Generation in the Ocean

Efim Pelinovsky[1], Christian Kharif[2], Tatiana Talipova[1], and Alexey Slunyaev[1]

[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. The mechanism of focusing of nonlinear wave field to explain the freak wave occurrence in the ocean is developed. First, the linear theory of amplitude-phase modulation is presented, and the conditions of the optimal focusing are obtained. Then, weak nonlinear theory of freak wave generation is given. For shallow water, the Korteweg – de Vries equation is used to demonstrate the features of the wave focusing. It is shown that large-amplitude abnormal impulse can be generated from the weak "invisible" deterministic (transient) component on the background of the random wind wave field. For deep water, the nonlinear Schroedinger equation for the complex amplitude of the wave envelope is applied. The mechanism of wave focusing is compared with well-known mechanism of the Benjamin-Feir instability. It is shown that the preliminary phase modulation can amplify the process of appearance of large-amplitude abnormal waves.