Some geometric and kinematic properties of breaking waves

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Introduction

The knowledge of the geometric and kinematic properties of rogue waves is important from a practical point of view. In-situ measurement is difficult because, among others, the sudden occurrence of these waves out of ordinary and the risk of damages with regard to the instruments. Experiments in laboratory are therefore needed.

An experimental method is proposed which was initially and specifically developed for breaking waves study, but which could be applicable, from our point of view, to rogue waves. Properties of breaking waves are also displayed which illustrate the feasibility of the method and provide a contribution to the knowledge of these category of "abnormal " waves.

Description of the method

Because the unstationnarity of the phenomenon, visualization appears to be a privileged way of investigation.

A quiet simple technique was developed in order to visualize the wave profile, it uses a thin sheet of light for illuminating the water surface previously tinted, and cameras looking perpendicularly to the light sheet.

Chronological series of video-pictures are recorded and stored on a videodisc.

The video-pictures are focused in stop frame mode on an electronic tablet where they are transformed into digital form for further measurements.

Application to plunging waves: geometric and kinematics properties

It is well known that breaking waves display an asymmetric shape, consequently, contrary to the case of sinusoidal waves, two parameters are no more sufficient for describing accurately their profile, and additional parameters have to be defined.

The horizontal asymmetry factor (μ), which describes the asymmetry of the wave with respect to an horizontal axis (the still water level), and the slope of the front part of the crest (ε), are of particular interest. Table I summarizes measurements of these two parameters at the breaking onset and show the significant asymmetry of the breaking wave profile.

As it is also well known, the asymmetry depends on the breaker type: this relationship was measured and Table II summarizes the results concerning the parameters ε and μ previously defined, as the parameters δ and λ which describe respectively the slope of the rear part of the crest and the asymmetry of the crest with respect to a vertical axis through this latter.

	Horizontal asymmetry factor	Crest front steepness

	μ	ε
Kjeldsen and Myrhaug (1979)	0.84 to 0.95	0.32 to 0.78
Bonmarin (1989)	0.76	0.54
Griffin et al. (1994)	0.71 to 0.80	0.26 to 0.60
Symmetric wave	0.50	0.28

Table I. Asymmetry of a plunging wave

	μ	ε	δ	λ
Typical plunging	0.77	0.62	0.28	2.13
Plunging	0.76	0.47	0.30	1.60
Spilling	0.75	0.41	0.31	1.37
Typical spilling	0.69	0.39	0.33	1.20

Table II. Relationship between profile asymmetry and breaker type

As about the kinematic properties, the attention was focused on characteristic zones of the wave surface: the zero-crossing points (the points where the crest profile crosses the still water level taken as reference), the crest, the face of the falling water jet and the back of the overturning region. It was shown that the celerity of the zero-crossing points is constant and not disturbed by the breaking event meaning that the breaking process concerns a region relatively close to the crest.
Celerity of the back of the overturning region and of the water jet are also constant, the celerity of the latter being equal in first approximation to the one of the crest before the breaking occurrence.

The real acceleration was measured on the surface of breaking waves and in the overturning region by means of floating tracers: the results are in relative good agreement with the numerical simulations by Vinje and Brevig.

Finally, preliminary experiments were performed on a weak adverse current (U/C = - 0.11, where C is the phase velocity). No significant influence of this current on the geometry of breaking waves was observed.

Conclusions and prospects

A visualization technique and an associated process for quantitative measurement were developed to study specially the geometric and the kinematics of breaking waves: from our point of view these means could be applicable helpfulness to rogue waves.
As about breaking waves on current, further experiments are currently considered in order i) to confirm the preliminary results recently obtained, ii) to inquire the action of stronger currents.