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Editorial

Editorial – Introductory remarks on "Discussion & Debate: Rogue Waves – Towards a Unifying Concept?"

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Abstract. This short editorial contains the introductory remarks for the special issue "discussions and debates" on the subject of "rogue waves". This issue is the first of its kind, in the sense that the authors have the chance to discuss the basic concepts of an emerging topic in science. Based on these discussions, an attempt to give a "definition" of a rogue wave is made.

The present special issue is devoted to rogue waves. This novel scientific term was born in nautical mythology, entered the science of ocean waves and gradually moved into other fields: optics, matter waves, superfluidity, etc. As with every other scientific term, it takes time to become established in the literature. The importance of correct usage of scientific terms cannot be overestimated. Accurate use of terms allows us to express ideas in their most concise forms. Thus, each time when we use a term, it should be understood by a large audience in the same way. Let us give simple examples. The terms "velocity", "acceleration" and similar basic scientific notions do not need explanation when we use them in scientific texts. Similarly, the term "soliton" is also becoming one of the basic scientific terms, though it can be restricted with additional words like "dissipative soliton". The more complicated notion "dynamical systems" is also largely understood by the scientific community uniformly, although there is no unique definition of it. Various books on dynamical systems treat the term in different ways, despite the fact that the contents of the books are similar. Thus, every new scientific term requires "discussions and debates" before being uniformly understood by everyone. Thus, introducing the term "rogue waves" requires the same procedure.

By now, a large volume of literature has appeared which uses the term "rogue waves". However, what is understood with this term by the authors varies. Existing books suggest several alternatives. Moreover, in parallel with "rogue waves", we can also find "freak waves", "killer waves", "extreme events" and other similar names. In addition, shortened 'particle' versions like "rogon", "freakon", etc. are also being suggested.

In addition to the necessity of dealing with several names, there is no strict definition of the phenomenon, although, intuitively, the authors of a multiplicity of publications assume that a rogue wave is a wave that is much higher than others around it, and which has a habit

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of appearing unpredictably. Spreading the research on rogue waves to other areas of physics and even to the economy did not improve the situation. When applied to diverse physical phenomena, a single definition does not really work.

Thus, anyone who would try to give a definition would be in a difficult position. What we can do is to summarise the existing knowledge and give certain recommendations based on the opinions of experts. Luckily, the aim of this special issue is to discuss the present situation and perhaps extract common ideas from these discussions that would help future researchers. In order to clarify the concept, we can suggest a few arguments. If they are considered in the context of the rogue wave phenomenon, it is our opinion that they would elucidate the position that the experts take and what they mean by this term.

The phenomenon is still mysterious and so complicated that any oversimplified definition is not adequate to illuminate all the issues. Thus, several constraints have to be imposed to narrow the concept. Here, we try to list these constraints in their order of importance.

1. In the science of ocean waves, there was a suggestion to call a wave "rogue" if its amplitude is more than twice (or 2.5 times) that of the average amplitude of the significant wave height. With some restrictions, this definition can be extended to other fields as well.
2. Another important feature of a rogue wave is its unpredictability. Figuratively speaking, a rogue wave is a wave that "appears from nowhere and disappears without a trace". Thus, to a large extent, the phenomenon is chaotic.
3. The third feature is related to the probability distribution function (PDF) of the wave amplitudes. Namely, large waves appear much more often than they would according to Gaussian statistics. Experimental studies on rogue waves usually produce elevated tails of the PDF.

   The above three restrictions are the main components of the definition that could be produced at this stage. However, several others have been also discussed in the existing literature.
4. Is the phenomenon of "rogue waves" linear or nonlinear? Present approaches are inclined to the version of their nonlinear nature. Indeed, linear theories of rogue waves can only produce Gaussian PDFs, so the appearance of large waves would have very small probability.
5. What is the onset of appearance of "rogue waves"? Is the phenomenon related to modulation instability? The latter question was first posed by Peregrine in his paper of 1983 in relation to ocean waves. There is little doubt that one or other form of instability is indeed responsible for generating large waves.
6. How does the spectral content of a wave field evolve in order to produce a rogue wave? In optics, as well as in other fields like capillary waves, the spectral content starts with a single or narrow spectral component that spreads, first into a triangular spectrum shape, while then later it creates a so-called "supercontinuum". In one form or other, this happens in other fields too.

Perhaps, six conditions are too many for a description of the phenomenon. Thus, restricting ourselves to only three will widen the possibilities for classifications. The necessity for clarifications can be one of the main features of the present state of research in the field. The reader of this special issue will find a variety of opinions in the papers and, in particular, in the special part of the issue "Discussions and Debates".

One of the major tendencies in the present state of the science is the spread of the concept from oceanography into several other areas of research. The contributors mention this expansion as a positive process. Indeed, the possibility of making experiments in other fields, which are less dangerous than the open ocean, is one of the great advantages of this process. Even though the results may not be immediately used for the prevention of rogue waves in shipping routes, a better understanding of their nature brings future technological achievements closer to our days.

Let us say a few words on the novel (perhaps even pioneering) feature of this particular special issue. In contrast to conferences and other presentations, printed material is less specific for real discussions and debates. However, the capacities of modern technology are unlimited. This is especially true for the internet, with its multiplicity of discussion sites on various subjects. Talking in modern terminology, the editors of this special issue opened a "blog" on rogue waves.

Namely, the content of this special issue was placed on a website, and experts had a chance to read the papers and make comments before the papers went to the publisher. The part of the issue "Discussions and Debates" as well as the whole issue, was formed in this way. Clearly, this kind of arrangement for discussions may not be a complete substitute for conferences where the exchange of ideas is an immediate process. However, the ability of contributors to place comments in an interactive format is one of the powerful features of 'blogs' like ours. Moreover, participants have more time to express ideas in clearer form than at the meetings. At the same time, in contrast to conferences, every point that contributors make is documented into printed form which can now be appreciated by a much wider audience.

To some extent, cross-viewing of the manuscripts on the web can also play the role of reviewing the papers. For special issues like this, where the papers are written by the leading experts in the field, this may not be really necessary. However, typos and certain delusions are always a possibility. Eliminating these is one of the major steps in any editorial work. The "D&D" style of operating this process could bring further improvements in the quality of published material.

As stated, the authors of this special issue are leading experts in the field. There is no real need to introduce them. The order in which the manuscript appears in the issue reflects the timing of its submission, rather than any other consideration. We hope the reader of this journal will enjoy reading the papers as much as we did when we received them. The centre piece of the issue is clearly the "D&D" part which follows the same rule. The discussion inputs appear in the order of submission.

A short introduction of each contribution here may be quite useful.

Victor Ruban, in his paper, presents a highly mathematical treatment of rogue waves in three-dimensional space, with one of the dimensions being considered as a perturbation. This approach allows us to consider more accurately the spontaneous formation of rogue waves in deep water.

Pelinovsky, Polukhina and Kurkin consider a mathematical model for edge rogue waves that appear in the coastal zones of the world's oceans. Their research shows that, even close to the shore, the ocean can be dangerous.

Onorato, Proment and Toffoli stress the modulation instability in crossing seas as a potential mechanism for the formation of freak waves. The study is based on two coupled nonlinear Schrödinger equations. Their model is a first step towards an understanding of the nonlinear dynamics that takes place when two wave systems overlap.

Ruderman extends the ideas of rogue waves to plasmas. In particular, he discusses the process of the generation of large amplitude wave groups in plasmas starting from small amplitude perturbations due to the modulation instability. Two wave modes are taken into account, viz. ion-sound waves and Alfvén waves.

Slunyaev considers the strong correlation in the spectrum area near the spectral peak related to Benjamin-Fair (modulation) instability which causes intense wave groups of unidirectional deep-water surface waves to act as freak events.

Soomere considers in detail rogue wave phenomena in shallow water in comparison with rogue waves in deep water. As rogue waves appear in coastal areas as often as in deep seas, this comparative study is highly important and it sheds light on several characteristic features of rogue waves near the shores.

Yeh, Li and Kodama consider reflections by a vertical wall of solitary waves described by the Kadomtsev-Petviashvili equation. The theory is complemented by laboratory experiments.

Zakharov, Dyachenko and Shamin consider an important issue for rogue waves: their statistics. The chances of meeting a rogue wave can and should be calculated in advance in order to reduce the probability of a fatal clash. This is indeed a problem of great practical importance.

Dudley et al. describe a number of challenges in understanding extreme wave phenomena in optics. These issues are studied in the framework of a multidisciplinary consortium aiming to carry out mathematical, numerical and experimental studies of the phenomenon.

Erkintalo, Genty and Dudley present numerical simulations that intend to revisit optical rogue wave statistics in supercontinuum generation.

Jalali et al. review the recent technology that allows us to capture rogue events in electronic signals, spectroscopy and imaging.

Kharif and Touboul consider the effect of wind on rogue waves and various models that can take into account the wind effect.

Bludov, Konotop and Akhmediev study, numerically, rogue waves in two component Bose-Einstein condensates with variable scattering lengths.

Efimov et al. report observation of rogue waves in superfluid helium. This work is an extension of rogue wave ideas to the micro-world. Rogue waves in this system appear in the nonequilibrium conditions after the external drive has been switched on, but before the steady state is established.

Grimshaw et al. examine the issue of whether rogue internal waves can be found in the ocean. As a mathematical model, they use the Gardner equation, which is an extended version of the Korteweg-de Vries equation with quadratic and cubic nonlinearities.

Lindgren, Bolin and F. Lindgren present two non-traditional stochastic models for ocean waves in two and three dimensions which have the potential to describe severe non-homogeneous sea conditions.

Osborne discusses important problems of classification, measurement and data analysis related to rogue waves. Highly non-trivial mathematical techniques are applied to the analysis and hyperfast numerical modeling of the phenomenon.

Dubbard et al. derive multi-Peregrine breather solutions to the nonlinear Schrödinger equation. These can be used as prototypes of rogue waves in hydrodynamics and in nonlinear optics. They also consider basic properties of multi-positon and positon-soliton solutions to the Korteweg-de Vries equation that may also describe rogue waves.

In the concluding paper of the issue, Akhmediev, Soto-Crespo and Ankiewicz suggest a controversial idea – the possible use of rogue waves as a weapon against enemy ships. The idea is transferred from research in optics, where solitons may be significantly amplified after collisions. In the wild world of real solitons, the fittest one survives and is elevated to the rank of a "rogue soliton".

In our view, this first attempt to organise the "D&D" type of special issue did justify the novel approach suggested by the editors of the European Physical Journal. Now, the reader has a chance to judge if this mission was indeed accomplished.