

Report on [Rogue Waves](#) Workshop

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Submitted by:

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Background

Rogue, or freak, waves is currently a very hot topic. At the same time, it is a topic of substance in nonlinear wave theory, and an ICMS workshop was timely and appropriate. Briefly, a rogue wave is the rare transient occurrence of a wave whose amplitude is significantly larger than the background sea-state. A commonly-used *ad hoc* definition is a wave that is at least 2.2 larger than the significant wave height. Although they are rare events, just how rare is not clear; a spate of recent ocean observations suggest they are not as rare as had been thought. These destructive waves are of major concern for shipping and off-shore engineering. Based on various numerical and analytical models, several dynamical mechanisms have been proposed for their occurrence; these included Fourier superposition of many small waves with suitable phase relations, nonlinear focussing of wave energy, and wave refraction by currents and/or topography. However, a detailed and definitive understanding of rogue waves, and related phenomena, is not presently available. Hence, it was felt that was a need for an ICMS workshop to look at rogue waves from a more mathematical and fundamental attitude.

Structure:

There were thirty-six participants, fifteen from UK, ten from EU, eight from US, two from Russia, and one from Japan. They included a broad cross-section of mathematicians interested in the theory of rogue waves, or more generally, transient large-amplitude waves, together with some more theoretically-minded physicists and engineers concerned with modelling and simulation aspects, and some scientists with observational, experimental and prediction concerns. A further sixteen people were invited, but were unable to come. The programme consisted of seven keynote lectures of one hour each, and twenty-one half-hour contributions. Each day concluded with a one-hour open discussion session. There were no significant deviations from the original accepted proposal.

Topics covered:

The talks ranged widely over many aspects of rogue waves, with a heavy and natural emphasis on water waves. Given the mix of mathematicians, theoretical and numerical modelers, and observationalists who made up the workshop, the wide-ranging of the talks and the discussion was inevitable and desirable. The talks were structured around four sub-topics, and the timetable was structured so that these were approximately followed in sequence; of course, due to constraints imposed by some participants travel plans, there were some deviations from this plan. In this list a “*” denotes a keynote lecture, and otherwise the speakers are listed in alphabetical order; however, note that the allocation to topics is somewhat arbitrary, as many talks covered more than one of these sub-topics.

- **Observation and experiments:** Although the emphasis in this workshop was on the role of mathematics in the modelling and prediction of rogue waves, it was essential that the discussions took place in the framework provided by the most up-to-date and reliable observational and experimental data.

[Kharif, Lavrenov, *Magnusson, *Melville, Rainey, Taylor, Waseda]

- **Wind-wave spectral models and statistical issues:** Currently, and for the foreseeable future, wind-wave prediction models are statistically based, and concerned therefore with the modeling and prediction of ocean wave spectra, rather than with specific discrete events. Nevertheless, it was important that the issue of predicting potential rogue wave events in an operational framework be a part of this workshop.
[Dysthe, Fullerton, Kaplan, Janssen, Nazarenko]
- **Numerical modeling (1D and 2D):** Because rogue waves have large amplitudes, it is clearly necessary that theoretical concepts, which can provide qualitative guidance, be combined with numerical simulations to provide quantitative information. Currently there are several reliable 1D (one horizontal space dimension) numerical codes which can describe water waves up to, and sometimes beyond, breaking limits, and a few 2D (two horizontal space dimensions) which are presently restricted to more modest amplitudes.
[Annenkov, Dias, *Grilli, *Grue, *Zakharov]
- **Analytical modeling and theory:** Since the workshop was intended to have a mathematical focus, this topic was essential and formed a central role in the workshop. The topics presented and discussed included Fourier superposition, directional focussing, nonlinear focussing of wave energy (based, for instance, on the nonlinear Schrodinger equation, Dysthe equation and related models), and wave refraction by both currents and topography.
[*Bona, Craig, van Groesen, Longuet-Higgins, *Peregrine, Onorato, Schober. Shrira, Soomere, Talipova, Vanden-Broeck]

Outcomes:

Our primary aims were two-fold. First, we wanted to focus the attention of mathematicians onto this important topic. Second, we aimed to provide a forum where mathematicians and modelers can mix constructively with engineers and experimentalists, with the outcome that clear directions for future research in this topic could be established. In our view both aims were achieved.

Current research indicates that the focussing of wave energy is a clear necessary ingredient for the occurrence of rogue waves. However, opinions differed as to whether this is achieved primarily through intrinsic nonlinear dynamics, or through essentially linear mechanisms of Fourier superposition, directional focussing, or wave refraction by currents and/or topography. Some of the issues identified by the participants as needing more fundamental research included the need for better and more definitive observations, for 2D numerical modelling with improved resolution, the extension of present theoretical models based on the nonlinear Schrodinger equation, or the Dysthe equation, to higher amplitudes and to two dimensions, the possible direct role of wind forcing, a better understanding of turbulence in the breaking wave environment and the need for more sophisticated statistical analyses.

Dissemination:

This will take place primarily through the ICMS web-site, where each contributor has been asked to post an extended abstract (up to 4 pages), and will be allowed to provide links to related publications and to their home page.

Organisation:

All the participants expressed great satisfaction with the logistical work of the ICMS staff, the overall organization and the stimulating experience of being in the “Maxwell” house.