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Rogue waves in terms of multi-point statistics and nonequilibrium thermodynamics

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Ocean waves, which lead to rogue waves, are investigated on the background of complex systems. In contrast to deterministic approaches based on the nonlinear Schroedinger equation or focusing effects, we analyze this system in terms of a noisy stochastic system. In particular we present a statistical method that maps the complexity of multi-point data into the statistics of hierarchically ordered height increments for different time scales.

We show that the stochastic cascade process with Markov properties is governed by a Fokker-Planck equation. Conditional probabilities as well as the Fokker-Planck equation itself can be estimated directly from the available observational data.

This stochastic description enables us to show several new aspects of wave states. Surrogate data sets can in turn be generated allowing to work out different statistical features of the complex sea state in general and extreme rogue wave events in particular. The results also open up new perspectives for forecasting the occurrence probability of extreme rogue wave events, and even for forecasting the occurrence of individual rogue waves based on precursory dynamics.

As a new outlook the ocean wave states will be considered in terms of nonequilibrium thermodynamics, for which the entropy production of different wave heights will be considered. We show evidence that rogue waves are characterized by negative entropy production. The statistics of the entropy production can be used to distinguish different wave states.