Stochastically Excited Nonlinear Ocean Structures

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PREFACE

There has been immense recent interest and progress in the study of nonlinear oscillators using advances in modern mathematics and physics. These studies have focused on characterizing, analyzing, and controlling instabilities which lead to bifurcation behavior ranging from period doubling to chaotic behaviors.

There has also been much attention, paid of late, to random processes exhibiting non-negligible frequencies of extreme events. These random processes are governed by probability distributions with long tails to account for extreme possibilities. As the tails of the distribution fall off algebraically slowly, the moments of the distributions can be large. (And even infinite.) The moments will not present a well defined characterization of the distribution or the stochastic process. Scaling laws arise in these cases of long tailed distributions and their exponents play a useful role in a description of the underlying random process.

The question naturally arises what happens if nonlinear oscillators are subjected to noisy random forces (mild and extreme)? How will the nonlinear oscillators respond? There will be regimes where the oscillator behavior is only slightly perturbed by noise, and other regimes where the effects of the noise dominate. The Navy's interests is in the behavior of ocean structures (ships, boats, piers, rigs, platforms, docks, etc) which are subjected to wind and waves. How do they respond in the short run to violent weather and in the long run to years of cyclic wear. Can ocean structures be better designed to withstand the extreme winds and waves of storms? Can lifetimes of structures be prolonged in the face of fatigue due to everyday stresses of typical wave and wind actions? These were the questions posed by the Office of Naval Research in a five year research program. The emphasis was on basic research. Both nonlinear oscillators and noise and their interactions were investigated.

The program has produced many avenues of attack for problems concerning the behavior of randomly driven nonlinear oscillators. The chapters in this volume approach these problems with analyses carried out in the time, frequency and phase space domains. In some cases the analysis proceeds via equations for probabilities as functions of position, time and velocity and in other cases the system models are cast directly as moment equations. Some of the studies focus the analysis in terms of power spectra, others consider directly time correlations, and still others consider first time passage probabilities. Overall a rich field of science is revealed with major contributions from mathematicians, scientists, and engineers.

The chapters are contributed by experts in nonlinear dynamics, stochastics, and civil engineering. The authors go beyond purely technical discussions to explain their scientific objectives, approach, and results. This collection of articles represents the state-of-the-art research of stochastically excited ocean structures.

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