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From: Computational Stochastic Mechanics – Theory, Computational Methodology and Application, edited by A. Cheng and C. Yang, Elsevier Applied Science, London (in press).

Deterministic and Stochastic Chaos

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ABSTRACT

Stochastic differential equations and classical techniques related to the Fokker-Planck equation are standard bases for the analysis of nonlinear systems perturbed by noise. An alternative, complementary approach applicable to systems featuring heteroclinic or homoclinic orbits uses phase space flux as a measure of noise-induced chaotic dynamics. We continue our development of this method, extending our previous treatment of additive noise to the more general case of multiplicative noise. This extension is used with a new model of shot noise to treat the Duffing oscillator with shot noise-like dissipation.

INTRODUCTION

Two fundamental paradigms are used to account for the seemingly unpredictable and erratic motions exhibited by many dynamical systems: the first is that of a dynamical system perturbed by noise - a differential equation, say, driven by white noise or jump noise. This type of motion is called stochastic chaos and is typically studied using stochastic differential equations and classical techniques related to the Fokker-Planck equation. Stochastic chaos exhibited by nonlinear systems is an ongoing object of intense interest [1, 2, 3, 4, 5]. Noise-induced state transitions in nonlinear systems, in particular, have received much recent attention [6, 7, 8, 9].

The second paradigm of erratic motion posits a purely deterministic dynamical system with 1) an uncertainty (perhaps very, very small) in its initial state and 2) a flow structure admitting intersecting stable and unstable manifolds. Such a system is capable of bounded motion which becomes increasingly unpredictable with the time