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Stochastic stability of Duffing oscillator with fractional derivative damping under combined harmonic and Poisson white noise parametric excitations

Weiyan Liu[a,*], Weiqiu Zhu[b], Lincong Chen[c]

[a] *School of Mathematics and Statistics, Taishan University,Taian 271000, PR China*
[b] *Department of Mechanics, State Key Laboratory of Fluid Power Transmission and Control, Zhejiang University, Hangzhou 310027, PR China*
[c] *College of Civil Engineering ,Huaqiao University,Xiamen, Fujian, 361021, PR China*

Abstract

The stochastic stability of a Duffing oscillator with fractional derivative damping under combined harmonic and Poisson white noise parametric excitations is investigated. A stochastic averaging method and the Khasminskiis procedure are applied to evaluate the largest Lyapunov exponent. Then the asymptotic Lyapunov stability with probability one of the original system is determined approximately by using the largest Lyapunov exponent. Finally, the analytical results are verified by those from the Monte Carlo simulation of the original system.

Keywords:
Stochastic stability, combined harmonic and Poisson white noise excitations, fractional derivative damping, the largest Lyapunov exponent

1. Introduction

In the past three decades, the stochastic stability of non-linear system is of a growing interest. There are many versions of stochastic stability [1-4], and the asymptotic stability with probability one is widely adopted. Based on the Oseledec multiplicative ergodic theorem [5], the necessary and sufficient condition for the asymptotic stability with probability one is that the largest Lyapunov exponent is negative. Khasminskii [6] proposed a procedure for evaluating the largest Lyapunov exponent of linear systems and later extended to non-linear systems with homogeneous drift and diffusion coefficients of degree one [7]. However, it is difficult to apply this procedure to systems higher than two dimensional directly, due to the difficulty of studying diffusion processes occurring on surface of unit hyperspheres in higher dimensional space. To overcome this difficulty, the stochastic averaging method can be used to reduce the dimension of stochastic dynamical systems first and then to apply Khasminskis procedure. Thus, the combination of the s-

*Corresponding author: Tel:+86 0538 6715169.
Email address: wyliu12@163.com (Weiyan Liu)