# Vibrations of Nonlinear Continua Subject to Combined Harmonic and Stochastic Forces: Linearization Approximations and Monte Carlo Simulations

Pol D. Spanos

L.B. Ryon Endowed Chair in Engineering, Rice University, Houston, TX (USA) 77005 Email: spanos@rice.edu.

**Abstract**

The objective of this lecture is to propose an efficient methodology for estimating reliably the second order statistics of the response of continua subject to combinations of harmonic and random loads. This issue is relevant in several engineering applications, where, for instance, the harmonic load is affected by a significant noise that can not be neglected when computing the response statistics.

The problems considered pertain to nonlinear vibrations of beams and plates endowed with fractional derivative elements. In both cases, it is shown that by representing the system response via the linear modes of vibration, systems of nonlinear fractional ordinary differential equations describing the time-dependent variation of the modes amplitudes are obtained. These stochastic ordinary differential equations are treated by combining in a novel manner the harmonic balance and statistical linearization techniques for deriving nonlinear coupled algebraic equations for the second-order statistics of the response. The coupled nonlinear algebraic equations can be readily solved using standard numerical analysis codes. Relevant Monte Carlo data are used for demonstrating the reliability of the proposed solution scheme.