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Special Guest Lectures

Polynomial Chaos and Uncertainty Quantification

Xiaoliang Wan, Division of Applied Mathematics, Brown University

Sea Grant College Program, MIT

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Abstract:
The inherent random nature of many physical and biological problems has long been recognized in science and engineering. However, most of the mathematical models used in applications are deterministic, where the influence of uncertainty, such as imprecise material properties and noise in boundary/initial conditions, is typically ignored. Due to the development in numerical algorithms, theory of stochastic PDEs and computational capability, there has been recently an intense interest in modeling uncertainty in large-scale simulations. In this talk I will present an overview of my research related to polynomial chaos methods for uncertainty quantification based on the following aspects: 1) Algorithm: Compared to Monte Carlo methods, (generalized) polynomial chaos (gPC) is a non-sampling strategy, which provides a spectral expansion of the target random process with respect to a set of random variables. The efficiency of the polynomial chaos expansion is determined by the regularity of random functions. To deal with low regularity in the parametric space, a new method, multi-element generalized polynomial chaos (ME-gPC), has been developed. ME-gPC provides dual paths of convergence, i.e., hp-convergence. In particular, I will address the adaptivity of ME-gPC method, which is important to enhance the efficiency of numerical computation. 2) Analysis: Two typical stochastic elliptic models will be addressed. In the first model, the ellipticity condition is satisfied almost surely. I will focus on the a posteriori error estimation of ME-gPC method for this model, which is used to develop an adaptive algorithm. In the second model, the problem is perturbed by spatial white noise, where the ellipticity condition is only required for the mean coefficient. I will focus on the convergence study of a stochastic finite element method developed in the weighted Wiener-chaos space. 3) Applications: I will show some applications of polynomial chaos methods in fluid mechanics.

Speaker's Bio:
Xiaoliang Wang is currently a Postdoctoral Research Associate at the Crounch Group & Center for Fluid Mechanics, Division of Applied Mathematics, Brown University and Sea Grant College Program, MIT. He received his Ph.D. in 2007 from Brown University. His research interests include: stochastic modelling; development, analysis and applications of multi-element generalized polynomial chaos (ME-gPC); stochastic partial differential equations; high-order numerical methods for PDEs; error control and adaptivity for deterministic (spectral/hp element) and stochastic (ME-gPC) numerical methods; and parallel scientific computing.