Weekly Seminar: Fall 2009

Date: September 25

Time: 11:00 AM

Location: Maryland Hall 110

Speaker: Youssef Marzouk

MIT, Cambridge MA

Title:*"Uncertainty quantification and statistical inference in transport and kinetic modeling"*

Abstract

Predictive simulation of natural and engineered systems increasingly rests on the interplay of experimental observations with computational models. Key inputs, parameters, or structural aspects of models may be incomplete or unknown, and must be developed from indirect and limitedobservations. At the same time, quantified uncertainties are needed to qualify computational predictions in the support of design and decision-making. In this context, Bayesian statistics provides a complete foundation for inference from noisy and limited data. Computationally intensive forward models, however, can render a Bayesian approach prohibitive.

We present new algorithmic developments for Bayesian inference in physical models, showing strong connections with the forward propagation of uncertainty. In particular, we introduce a stochastic spectral formulation that accelerates the Bayesian solution of inverse problems via rapid evaluation of a surrogate posterior distribution. The posterior is constructed by either stochastic collocation or stochastic Galerkin methods. Theoretical convergence results are verified with several numerical examples---in particular,parameter estimation in transport equations and in chemical kinetic systems. We also extend this approach to the inference of spatially inhomogeneous transport properties in a hierarchical Bayesian setting, achieving dimensionality reduction via Karhunen-Loeve representations of Gaussian process priors.

Finally, we discuss the utility of stochastic spectral methods in optimal experimental design---choosing experimental conditions to maximize information gain in parameters or outputs of interest. A Bayesian formulation of the design problem fully accounts for uncertainty in the parameters and relevant observables.