PIMS / AMI Seminar

Tuesday, October 26, 2010
3:30 p.m.
CAB 657

Applied Mathematics Institute

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"Numerical Methods for Dynamical Systems
Harmonic Balance (HB) and Non-Standard Finite Difference (NSFD)"

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Abstract

For very high dimensional dynamic systems in many fields of science and engineering, accuracy and computational cost are two critical issues for the choice of the numerical solution methods. Recently there has been substantial progress in developing new solution methods for addressing these two issues: the High Dimensional Harmonic Balance (HDHB) method and the Non-Standard Finite Difference (NSFD) method. These two distinct methods have been developed originally in the fields of aerospace engineering and physics separately.

The HDHB method was developed starting from the conventional harmonic balance (HB) method. Directly finding the steady state solutions while avoiding the need to calculate the long and computationally expensive transient time histories, the HB methods are very efficient and useful for characterizing and predicting the responses of nonlinear dynamical systems undergoing periodic or quasi-periodic oscillations. The traditional HB method provides accurate result yet is virtually impossible to implement for high dimensional systems. The HDHB method can be implemented easily for high dimensional systems yet may provide physically spurious solutions in some cases. The NSFD schemes have the dynamic consistency with the original systems, and the appropriate time marching step sizes are usually larger than those required in the standard finite difference schemes. The NSFD schemes are constructed based on the mathematical structures of the dynamical systems and thus need to be constructed for each unique system. In the current literature, the NSFD schemes have been constructed for low dimensional ordinary differential equations systems and for some special partial differential equations.

In this talk, first the basic idea and some theory of the HB and NSFD methods are briefly introduced. The talk then focuses on the applications in engineering. The illustration schemes are constructed for some model equations including the Duffing's equation, the Van der Pol equation, the reaction-diffusion equation and finally the Burgers type equations. The HB, NSFD schemes and the numerical simulation results are presented. Finally, the advantages and disadvantages of the HB and NSFD methods are concluded, in comparison with the traditional time marching methods.

Refreshments will be served in CAB 649 at 3:00 p.m.