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Visions for Quantitative Biology Lecture Series

Spacetime Discontinuous Galerkin Methods in Classical Mechanics and Prospects for Applications to CFD and General Relativity

Robert Haber
Professor of Theoretical and Applied Mechanics
Johnston Hall 338
April 03, 2006 - 12:00 pm

Abstract:
This talk introduces spacetime discontinuous Galerkin (SDG) finite element methods, a novel paradigm for high-resolution, multiscale simulation in computational mechanics. Haber begins with an invariant spacetime formulation of classical mechanics using the tools of differential forms and the exterior calculus on manifolds. A straightforward Bubnov-Galerkin projection generates finite element methods with element-wise balance properties on spacetime grids and with suitable jump conditions for problems with shocks or other discontinuities. If the spacetime mesh satisfies a special causality constraint, then mesh generation and the finite element solution can be interleaved in a patch-by-patch procedure with linear complexity in the number of elements. An adaptive spacetime meshing scheme produces unstructured spacetime grids with extreme refinement ratios as large as 10^6 on a serial processor. However, the algorithm has a natural parallel structure, so even stronger mesh grading is possible on parallel systems. Haber demonstrates the method's application to several problems, including elastodynamic fracture, thermomechanical response with hyperbolic conduction, and atomistic-to-continuum coupling. Haber presents a CFD application of an SDG solution scheme for nonlinear conservation laws to initiate follow-on discussions of how SDG methods might be applied to hyperbolic models of general relativity.

Speaker's Bio:
Robert B. Haber is Professor of Theoretical & Applied Mechanics at the University of Illinois at Urbana-Champaign; he directs the Center for Process Simulation & Design, a multidisciplinary research center with primary funding from the NSF Information Technology Research (ITR) program. He received the Bachelors degree in Architecture from Cornell University in 1977 and the Ph.D. degree in Civil Engineering in 1980, also from Cornell. He is a fellow of both the International and the U.S. Associations for Computational Mechanics.