Frontiers of Scientific Computing Lecture Series

Finite element exterior calculus: a new approach to the stability of finite elements

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Abstract:
The finite element method is a vastly developed technology which is surely one of the most important tools of scientific computing. Nonetheless fundamental challenges remain in the design and understanding of finite element methods for certain important classes of problems, including in key areas like electromagnetism and elasticity. A powerful new approach--known as the finite element exterior calculus--has recently enabled substantial advances to long standing open problems such as the development of stable mixed finite elements for elasticity in two and three dimensions. The key to the new development is the achievement of stability by developing discretizations which are compatible with the geometrical and topological structures which mathematicians have developed to explore the well-posedness of the PDE problem being solved.

Speaker's Bio:
Douglas N. Arnold is Director of the Institute for Mathematics and its Applications, and Professor of Mathematics at the University of Minnesota. The primary mission of the IMA is to increase the impact of mathematics by fostering interdisciplinary research linking mathematics with important scientific and technological problems from other disciplines and industry. The IMA is a partnership of the National Science Foundation, the University of Minnesota, and a consortium of participating universities, laboratories, and corporations, and represents the largest mathematics research investment of the National Science Foundation. Professor Arnold's research interests include numerical analysis, partial differential equations, mechanics, and in particular, the interplay between these fields. Much of his work has concerned finite element methods, with the main applications being to the numerical simulation of elastic plates and shells, and also of incompressible fluids. He also works in computational relativity, with the long-term goal of the numerical simulation of massive astrophysical events, such as black hole collisions, and the resulting gravitational radiation emission. Around 2002 he initiated the finite element exterior calculus, a new approach to the stability of finite element methods based on geometric and topological structure underlying the relevant partial differential equations. The development of the finite element exterior calculus is a major direction of his current research work. Professor Arnold received his Ph.D. degree in Mathematics from the University of Chicago in 1979. From 1979 through 1989 he was on the faculty of the University of Maryland. In 1989 he moved to Penn State University where he was appointed Distinguished Professor Mathematics, and where he remained until assuming the position of Director at the Institute for Mathematics and its Applications in August 2001. Arnold has written about 75 papers, serves on the editorial boards of numerous journals, and has been designated as a Highly Cited Author by Thomson ISI. In 1991 he was awarded the first International Giovanni Sacchi Landriani Prize by the Academy of Arts and Letters of Lombardy Institute in Milan in 1991 for "outstanding contributions to the field of numerical methods for partial differential equations." In 2002 he was a plenary lecturer at the International Congress of Mathematicians in Beijing and in 2006 a member of the Program Committee for the International Congress of Mathematicians in Madrid. Arnold serves on a variety of advisory and scientific boards, including those of the Society of Industrial and Applied Mathematics (the SIAM Council), the Mathematical and Physical Sciences Directorate of the National Science Foundation, DIMACS, the Centre of Mathematics for Applications in Oslo, and the Maxwell Institute for Mathematical Sciences in Edinburgh. He is also a member of the US National Committee for Mathematics. At Penn State he was awarded the George W. Atherton Award for Excellence in Teaching by the University in 1996, the Teresa Cohen Service Award by the Mathematics Department in 1998, and the Distinguished Service Award by the Eberly College of Science in 2000. There he also served as co-director of the Center for Computational Mathematics and Applications and as associate director of the Institute for High Performance Computing Applications, and was a member of the Center for Gravitational Physics and Geometry.

This lecture has a reception.

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