Tidigare seminarier i beräkningsmatematik

2015

Måndag 8 juni 2015, Daniel J. Bodony, University of Illinois

Titel: Advances in SBP-SAT-based methods for the prediction and control of compressible turbulent flows

Sammanfattning: The accurate simulation of compressible turbulent flows places heavy demands on the underlying numerical methods to capture the large range of spatial and temporal scales of motion without adding numerical dissipation, especially in the presence of complex geometries. When an adjoint-based design methodolgy is to be used, additional demands arise to ensure accuracy of the gradient and meaningful interpretation of the sensitivity field. This presentation will discuss new developments towards provably stable numerical schemes, without artificial dissipation, appropriate for the prediction and control of compressible turbulent flows in the presence of complex geometries. We leverage the summation-by-parts / simultaneous-approximation-term (SBP-SAT) framework. In particular we will focus on (a) fully discrete and dual consistent adjoint-based gradients, (b) provably stable approximations for d/dx(a(x,t) du/dx), and (c) provably stable methods for overset grids. Examples will be given demonstrating the developments.

2014

Onsdag 4 juni 2014, Thomas Hagstrom, Southern Methodist University, USA

Titel: Artificial Boundary Conditions for Wave-propagation and Flow Problems

Sammanfattning: TBA

Måndag 10 mars 2014, Brittany Erickson, Portland State University, USA

Titel: Provably Stable Computational Methods for Solving time-dependent PDEs with an application to Earthquake Cycle Modeling

Sammanfattning: Mathematical models for earthquake nucleation and propagation must contend with highly varying temporal and spatial scales of elastic motion on faults, geometric irregularities in fault slip surfaces, nonlinear friction laws, heterogeneous material properties, and inelastic response of the solid Earth. We use high-order accurate finite difference methods to incorporate these physical and geometrical complexities and weak enforcement of boundary conditions through the SBP-SAT technique in order to develop provably stable numerical methods. Many of the challenges that arise are in fact common in Earth Science: the equations governing motion in the Earth can be highly nonlinear, numerically stiff, involve problems of constrained optimization, and have complicated interface and boundary conditions that can be very challenging to incorporate into a computational procedure. To illustrate how our methods address these difficulties, I will share results from earthquake cycle simulations within heterogeneous basins of sediment common to several major faults worldwide and conclude with a discussion of how these results give insight into some outstanding questions in earthquake science.

2013

Tuesday 12 February 2013, Remi Abgrall, Institut de Mathematiques de Bordeaux, University of Bordeaux, Talence, France

Title: High order preserving residual distribution schemes for advection-diffusion like problems on arbitrary grids, application to the Navier Stokes equations

Abstract: In this talk, we deal with the construction of a class of high order accurate Residual Distribution schemes for advection-diffusion-like problems using conformal meshes. We start by considering scalar problems. For this, we consider problems that range from pure diffusion to pure advection. The approximation of the solution is obtained using standard Lagrangian finite elements and the total residual of the problem is constructed taking into account both the advective and the diffusive terms in order to discretize with the same scheme both parts of the governing equation. To cope with the fact that the normal component of the gradients of the numerical solution is discontinuous across the faces of the elements, the gradient of the numerical solution is recovered at each degree of freedom of the grid and then interpolated with the same shape functions used for the solution. Linear and non-linear schemes are constructed and their accuracy is tested with the discretization of advection-diffusion and anisotropic diffusion problems. Then, by a formal extension of this method, we show its efficiency on the Navier-Stokes equations.

Tuesday 5 February 2013, David Zingg, Institute for Aerospace Studies, University of Toronto, Canada

Title: Explorations in Numerical Aerodynamic Shape Optimization

Abstract: This presentation will describe recent research in aerodynamic shape optimization based on the numerical solution of the Euler and Reynolds-averaged Navier-Stokes equations. The basic methodology includes a parallel implicit flow solver based on SBP-SAT finite-difference schemes on multi-block structured grids combined with a discrete adjoint approach to gradient computation along with B-spline based geometry parameterization and an efficient integrated approach to mesh movement. Topics covered will include the flow solution algorithm, geometry parameterization and mesh movement, the adjoint method, gradient-based optimization algorithms for multi-modal problems, and application to the design of unconventional aircraft.

Thursday 24 January 2013, Per Pettersson, Stanford and Uppsala University

Title: Uncertainty Quantification and Numerical Methods for Conservation Laws

Abstract: The aim of uncertainty quantification in computational fluid dynamics is to develop methods to describe the impact of limited knowledge in complex problem settings. In this talk we consider conservation laws with known probabilistic information in terms of distribution functions for input conditions. The input uncertainty is propagated through the governing PDEs to output quantities of interest. The solutions of the conservation laws are represented by a generalized chaos expansion in stochastic basis functions. The stochastic Galerkin method is used to project the governing equations onto the stochastic basis functions to obtain an extended deterministic system.

We investigate numerical properties of interest for the stochastic Galerkin formulation of an advection-diffusion problem with uncertain viscosity. Next we apply the stochastic Galerkin method to Burgers' equation with uncertain boundary conditions and give a qualitative description of the solution in terms of smoothness properties.

We present a new fully intrusive method for the Euler equations based on a Roe variable transformation. This saves computational cost compared to the formulation based on expansion of the conservative variables. Moreover, it is more robust and can handle cases of supersonic flow, for which the conservative variable formulation fails to produce a bounded solution. Finally, we present a hybrid method for a two-phase problem where spatial solution regions of varying smoothness are coupled weakly through interfaces. In this way, we couple smooth solutions solved with high-order finite difference methods with non-smooth solutions solved for with shock-capturing methods.

Tuesday 15 January 2013, Jens Berg, Division of Scientific Computing, Uppsala University

Title: Stable and high-order finite difference methods for multipysics flow problems

Abstract: This talk summarizes recent developments for the summation-by-parts (SBP) finite difference method with weak imposition of boundary and interface conditions using the simultaneous approximation term (SAT). The focus is on stable and high-order multiphysics and adjoint problems.

In the first part of this talk, we show how to construct stable boundary and interface procedures for computational fluid dynamics problems, in particular for problems related to the Navier-Stokes equations and conjugate heat transfer.

In the second part, it is shown how to utilize duality to construct numerical schemes which are not only stable, but also dual consistent. Dual consistency alone ensures superconvergence of linear integral functionals from the solutions of SBP-SAT discretizations. By simultaneously considering well-posedness of the primal and dual problems, we show how to derive new advanced boundary conditions with desirable discretization properties.

2012

Tuesday 4 December 2012, Thomas Hagstrom, Southern Methodist University, USA

Title: Towards the Ultimate Solver for Wave Equations in the Time Domain

Abstract: Efficient time-domain solvers for wave propagation problems must include three crucial components:

i. Radiation boundary conditions which provide arbitrary accuracy at small cost (spectral convergence, weak dependence on the simulation time and wavelength)

ii. Algorithms for using the information at or near the boundary to directly propagate the solution to remote locations - avoid sampling the wave whenever possible.

iii. Reliable high-resolution volume discretizations applicable in complex geometry (i.e. on grids that can be generated efficiently) - we believe that high-resolution methods enabling accurate simulations with minimal dofs-per-wavelength are necessary to solve difficult 3 + 1-dimensional problems with the possibility of error control.

In this talk we will discuss recent developments in all three areas, including our own work on the construction of complete radiation boundary conditions (CRBCs), which are optimal local radiation conditions, as well as novel spectral elements based on Hermite interpolation.

Tuesday 27 November 2012, Sofia Eriksson, Division of Scientific Computing, Uppsala University

Title: Stable Numerical Methods with Boundary and Interface Treatment for Applications in Aerodynamics

Abstract: In numerical simulations, problems stemming from aerodynamics pose many challenges for the method used. Some of these are addressed in this thesis, such as the fluid interacting with objects, the presence of shocks, and various types of boundary conditions.

Scenarios of the kind mentioned above are described mathematically by initial boundary value problems (IBVPs). We discretize the IBVPs using high order accurate finite difference schemes on summation by parts form (SBP), combined with weakly imposed boundary conditions, a technique called simultaneous approximation term (SAT). By using the energy method, stability can be shown.

The weak implementation is compared to the more commonly used strong implementation, and it is shown that the weak technique enhances the rate of convergence to steady state for problems with solid wall boundary conditions. The analysis is carried out for a linear problem and supported numerically by simulations of the fully non-linearNavier Stokes equations.

Another aspect of the boundary treatment is observed for fluid structure interaction problems. When exposed to eigenfrequencies, the coupled system starts oscillating, a phenomenon called flutter. We show that the strong implementation sometimes cause instabilities that can be mistaken for flutter.

Most numerical schemes dealing with flows including shocks are first order accurate to avoid spurious oscillations in the solution. By modifying the SBP-SAT technique, a conservative and energy stable scheme is derived where the order of accuracy can be lowered locally. The new scheme is coupled to a shock-capturing scheme and it retains the high accuracy in smooth regions.

For problems with complicated geometry, one strategy is to couple the finite difference method to the finite volume method. We analyze the accuracy of the latter on unstructured grids. For grids of bad quality the truncation error can be of zeroth order, indicating that the method is inconsistent, but we show that some of the accuracy is recovered.

We also consider artificial boundary closures on unbounded domains. Non-reflecting boundary conditions for an incompletely parabolic problem are derived, and it is shown that they yield well-posedness. The SBP-SAT methodology is employed, and we prove that the discretized problem is stable.

Tuesday 6 November 2012, Professor Per Weinerfelt, Linköping University, and SAAB

Title: Mathematical models for helicopter dynamics

Abstract: The talk will focus on physical and mathemathical models describing the dynamical behaviour of an helicopter in hover and forward flight. Mechanical components such as the helicopter rotor hub and the swash plate will also be briefly discussed.

Tuesday 2 October 2012, Peter Eliasson, FOI

Title: The flow solver Edge - an overview of capabilities, research and applications

Abstract: The Edge flow solver is being developed by FOI and is a Navier-Stokes code for unstructured grids. Today the code is developed in cooperation with Swedish and international partners and is the main CFD tool for Saab aeronautics. The talk will give an overview of the functionalities in Edge including aerodynamic design, gradient based shape optimization, turbulence and transition modelling, flow control and fluid-structure interaction. Some recent research activities related to numerical and physical modelling will be highlighted and a wide range of applications will be shown.

Thursday 27 September 2012, Zhong-Zhi Bai, Institute of Computational Mathematics and Scientific/Engineering Computing, Academy of Mathematics and Systems Science, Chinese Academy of Sciences, Beijing

Title: Preconditioning and Iterative Methods for Complex Linear Systems

Tuesday 8 May 2012, Matts Karlsson, IEI, Linköping University

Title: Computational Fluid Dynamics -- Biofluids, Aerodynamics and Industrial Applications

Tuesday 6 March 2012, Jan Nordström, MAI, Linköping University

Abstract: The current activities in computational mathematics at MAI regarding methods for fluid flow, wave-propagation, heat conduction and signal propagation will be discussed. The talk will give a brief presentation of the specific theoretical problems, the specific research issue and provide a ground for a discussion about possible collaborations in related application fields. The talk will also briefly mention current international collaborations with other universities.

This talk is the first in a new seminar series where we try to marry the use of Computational Mathematics and Mechanics (CMM) at Linköping University. All current users of computational techniques, in all application fields are welcome.

24 January 2012, Mark H. Carpenter, Computational AeroSciences Branch, NASA Langley Research Center

Title: Recent Advances for Energy-Stable WENO Schemes

Abstract: Weighted Essentially NonOscillatory (WENO) schemes are routinely used to perform high resolution simulations of canonical problems containing discontinuities. Because conventional WENO formulations rely on structured meshes, extension to complex geometries is problematic. Herein, we demonstrate a general multi-block WENO capability, based on uniformly accurate fourth-order and sixth-order, finite-domain, Energy Stable WENO (ESWENO) operators. The new ESWENO operators feature boundary closures that maintain design accuracy, conservation and L2 stability, while accommodating full WENO stencil biasing. Test cases are presented that demonstrate the efficacy of the new approach.

2011

20 October 2011, Eric Dunham and Post Doc Jeremy Kozdon from Department of Geophysics, Stanford University

Title: Computational Models of Earthquake Ruptures and Volcanic Eruptions

Abstract: The rich set of physics underlying earthquakes and volcanoes offers many interesting modeling challenges to the applied mathematician. For earthquakes, we must solve the elastic wave equation with nonlinear interface conditions involving jumps in fields across internal fault surfaces. The latter are friction laws expressing fault strength in terms of sliding velocity and internal state variables that evolve according to differential equations. We present a numerical method based on summation-by-parts difference operators with boundary and interface conditions enforced weakly using the simultaneous-approximation-term method. The versatility of the method is illustrated with a simulation of the 2011 magnitude 9.0 Tohoku-Oki, Japan, earthquake. Our group is also investigating seismic waves from volcanic eruptions. Here we must solve for flow of a compressible, viscous fluid (magma) through cracks and conduits in a deformable solid. The flow is described by quasi-one-dimensional mass and momentum balance equations with an isothermal equation of state. These equations are coupled to the elastic wave equation in the solid through changes in conduit cross-sectional area and force balance across the conduit walls.

Numerical simulations reveal that the wavefield is dominated by guided waves propagating along the conduit and involving motion of both the fluid and solid. Analysis of the linearized equations explains the dispersive nature of these waves, and shows how the restoring force responsible for wave motion comes from both fluid compressibility and elasticity of the conduit walls.

21 March 2011, Berkant Savas, MAI, Linköping University

Titel: Large scale graph/network computations and tensor computations

Abstract: In this seminar I will give an overview of the research problems that I have worked on during the two years of my postdoc at UT Austin. The presentation will include short discussions on the following topics: (1) Clustered low rank approximations. (2) Large scale computations for graphs and network problems, e.g., link prediction in dynamic networks, incorporation of multiple sources of information for link prediction and group recommendation. (3) Stochastic methods for large scale low rank matrix approximation. (4) Low multilinear rank approximation of tensors using Krylov-type methods. (5) Perturbation theory for low rank tensor approximations. (6) Optimization methods for problems defined on Stiefel manifolds.

If time permit, I will also mention a few research directions I plan to working on.