Oberseminar Numerik am 14.06.12

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"Efficient timestep adaptation for unsteady compressible fl ows via adjoint error control"

Abstract:
We report on adaptive timestep control for weakly instationary problems.
The core of the method is a space-time splitting of adjoint error representations for target functionals due to Süli and Hartmann. It provides an efficient choice of timesteps for implicit computations of weakly instationary flows. The main new ingredients are
(i) a conservative formulation of the dual problem
(ii) the derivation of boundary conditions for a new formulation of the adjoint problem
(iii) the coupling of the adaptive time-stepping with spatial adaptation.

Due to Galerkin orthogonality, the dual solution does not enter the error representation as such. Instead, the relevant term is the difference of the dual solution and its projection to the finite element space. We can show that it is therefore sufficient to compute the spatial gradient of the dual solution. This gradient satisfies a conservation law instead of a transport equation, and it can therefore be computed with the same algorithm as the forward problem, and in the same finite element space. For this new conservative approach we will derive boundary conditions.

For the spatial adaptation, we use a multiscale-based strategy developed by S. Müller (IGPM, RWTH Aachen), and we combine this with an implicit time discretization. The combined space-time adaptive method provides an efficient choice of timesteps for implicit computations of weakly instationary flows. The timestep will be very large in regions of stationary flow, and becomes small when a perturbation enters the flow field.

First we demonstrate the capabilities of the approach for a weakly instationary test problem for scalar, 1D conservation laws. Then we extend the computations to the 2D Euler equations, where we couple the adaptive time-stepping with spatial adaptation. The combined space-time adaptive method provides an efficient choice of timesteps for implicit computations of weakly instationary flows. The timestep will be very large in regions of stationary flow, and becomes small when a perturbation enters the flow field. The efficiency of the solver is investigated by means of an unsteady inviscid 2D flow over a bump.