Applied Mathematics

Modelling and Simulation for thermal structure interaction

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We consider the interaction between a compressible fluid and a structure by heat transfer. Applications can be found in steel cooling, reentry of vehicles from space, jet engines and rocket nozzles. The problem can be modelled using the compressible Navier-Stokes and a nonlinear heat equation with coupling conditions on an interface between the two corresponding domains. Of particular importance are then partitioned methods to solve the coupled problem, which reuse existing methods for the subproblems. The standard method is the Dirichlet-Neumann iteration where subsequently, Dirichlet and Neumann conditions are prescribed for the subproblems.

In practice, it is found that this iteration is really fast for thermal fluid structure interaction problems. On the other hand, it is known to be slow in domain decomposition. We present new results on convergence rates of the iteration for coupled linear heat equations, discretized using finite elements in space and the implicit Euler method in time. In 1D, we provide an exact formula and an estimate in 2D. These allow to compute the semidiscrete limits in space and in time, which turn out to be different ratios of coefficients of the heat equation. This allows to explain the fast convergence, as well as other phenomena, for example the possibility of causing divergence when refining the time step.

This is joint work with Azahar Monge.