Time-Adaptive Methods for the Incompressible Navier-Stokes Equations with High Order Accuracy in the Pressure Component

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Several classes of time stepping schemes are available for the simulation of incompressible fluids. In this talk we concentrate on implicit and linear-implicit Runge–Kutta methods since these methods allow an easy implementation of adaptive timestep control and allow higher order approximations.

Onestep methods have usually order reduction if they are applied on stiff ODEs. In the simulation of the incompressible Navier–Stokes equations this effect can usually observed in the pressure component. One well-known example of a stiff ODE is the example of Prothero and Robinson. We apply Rosenbrock-Wanner (ROW) methods on this problem and obain new order conditions which help us to improve the numerical order of convergence.

In comparison to DIRK and ROW methods a high dimensional nonlinear system of equations has to be solved in the case of the fully implicit Radau-IIA methods. This system can be transformed into smaller ones if the simplified Newton method is used. Then the solution of the linear systems can be computed in parallel with the help of the Component Template Library. The benefit of these Radau methods is the high order of convergence.

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