

On the time integration of stiff advection-diffusion-reaction equations

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Time integration of stiff, large-scale advection-diffusion-reaction equations by means of standard Runge-Kutta and linear multistep methods is often not feasible due to efficiency or memory restrictions.

We discuss a special method of Runge-Kutta-Chebyshev type, which handles advection and diffusion terms explicitly and stiff reaction terms implicitly. Assuming finite-volume or finite-difference spatial discretization, this RKC method handles moderately stiff diffusion terms efficiently due to stabilization by the three-term Chebyshev recursion. Advection terms can be treated with CFL numbers common for explicit methods assuming upwind discretization. Stiff reaction terms pose no stability step size restrictions at all provided reaction Jacobians possess real eigenvalues. For PDE systems with many components and highly expensive chemistry, it is easy to use parallelization because the chemistry computation is completely decoupled over the grid when finite-volume or finite-difference spatial discretization is used.

J.G. Verwer, B.P. Sommeijer (2003), An implicit-explicit Runge-Kutta-Chebyshev scheme for diffusion-reaction equations.

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J.G. Verwer, B.P. Sommeijer, W. Hundsdorfer (2004), Incorporating advection in the Runge-Kutta-Chebyshev method, J. Comp. Phys. (to appear). Preprint can be obtained from <http://homepages.cwi.nl/~janv/>