Optimally zero-stable superconvergent IMEX Peer methods

Rüdiger Weiner (Martin Luther University Halle-Wittenberg), Behnam Soleimani, Jens Lang, Moritz Schneider

Many systems of ODEs are of the form

$$y' = f(t, y) + g(t, y)$$

with stiff part f and nonstiff part g, for instance MOL discretizations of diffusion-advection-reaction equations. This kind of problems can be treated efficiently by implicit-explicit (IMEX) methods. In IMEX methods the stiff part is solved by an implicit method, the nonstiff part is solved by an explicit method.
In this talk we consider s-stage IMEX peer methods of order $p = s$ for variable and of order $p = s + 1$ for constant step sizes. They are combinations of s-stage superconvergent implicit and explicit peer methods. Due to their high stage order no order reduction appears. This is in contrast to one-step IMEX methods. On the other hand compared with multistep methods there is no order bound for A-stability of the implicit part.
We construct methods of order $p = s + 1$ for $s = 3, 4, 5$ where we compute the free parameters numerically to give good stability with respect to a general linear test problem frequently used in the literature. Numerical tests and comparison with two-step IMEX Runge-Kutta methods confirm the high potential of the superconvergent IMEX peer methods.