Improving the initialization of some integrators for index-3 DAEs and related stiff ODEs

Martin Arnold (Martin Luther University Halle-Wittenberg)

The direct application of ODE time integration methods to higher index DAEs results in numerical solutions that satisfy constraint equations with high accuracy but show a systematic deviation from the manifold that is defined by hidden constraints being obtained by differentiation of the original constraints with respect to time.
Consistent initial values of the analytical solution comply with all the original and hidden constraints in the DAE and do not share the systematic deviation of the numerical solution from hidden constraint manifolds. Therefore, some correction terms need to be added if these (analytically) consistent intial values are used for the initialization of the numerical solution since otherwise large transient error terms and order reduction may be observed in some of the solution components.
In the talk, we will discuss such improved initialization schemes for BDF and for generalized-α methods being applied to a class of semi-explicit index-3 DAEs on linear spaces or on Lie groups. Guided by this analysis for constrained systems, we extend the error analysis to second order ODEs with very stiff potential forces and discuss an improved initialization scheme for Newmark type integrators like the generalized-α method.

(The talk is based on previous joint work with O. Brüls (Liège, Belgium) and A. Cardona (Santa Fe, Argentina) on generalized-α methods and with V. Wieloch (Halle (Saale), Germany) on Lie group BDF time integration.)