Numerical solution of penalty formulations for constrained mechanical systems using the heterogeneous multiscale method

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The heterogeneous multiscale method (HMM) extends the rather analytical methods of averaging to a purely numerical approach for the solution of problems involving multiple scales. Especially for highly oscillatory ordinary differential equations HMM was recently seen to be competitive with usual time integration schemes. We study this hypothesis in the special case of penalty formulations for index-three differential-algebraic equations arising in multibody dynamics which have the particular property of solution-dependent oscillations with nonconstant frequencies.
In a first part of the talk we motivate some additional assumptions on the structure of the proposed problems and give error estimates extending the results of Engquist et al. Nevertheless numerical test problems of small and moderate size give rise to doubts on the applicability to realistic problems at least in the case of several or even multiple constraints.
To circumvent this lack in efficiency in the second part of the talk we propose a combination of HMM and co-simulation techniques and apply the resulting multiscale schemes to coupled PDE-DAE problems. Numerical tests including problems in nonlinear elasticity and fluid-structure interaction are presented and demonstrate the potential of this approach.