The Chromatography Analysis andDesign Toolkit (CADET)

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Chromatography is widely used for the industrial separation of biopharmaceuticals such as proteins and antibodies. We have implemented a fast and accurate simulator for the well-known General Rate Model of column liquid chromatography. A coupled set of partial and ordinary differential-algebraic equations is discretized in space and time using finite volumes and a BDF scheme. Sensitivities are computed with arbitrary precision by solving symbolic and algorithmic parameter derivatives of the original system equations. Our code is parallelized for shared memory architectures, and combined with an optimization framework for solving various inverse problems in the filed of separation science.

CADET is a software framework for model-based analysis and design of chromatographic separation processes. The first inverse problem is to calibrate the model against measurement data. Our framework allows to simultaneously evaluate data from different process states by setting up several instances of the GRM with the same parameters but different boundary conditions. This procedure increases robustness of the parameter estimation against measurement uncertainties and helps to detect experimental outliers. Calibrated models can be applied for separation processes with respect to performance indicators of the chromatogram. We can also compute sensitivities of these indicators with respect to disturbances in the composition of inlet feeds.

The speed and parallelism of CADET allow to perform Monte Carlo simulations for statistically analyzing the nonlinear impact of uncertainties in the input data, parameters, and boundary conditions on the solutions of forward and inverse problems. These simulations can also be used for designing future experiments with maximal information gain and minimal parameter correlations. Monte Carlo simulations are also very useful for robustness studies.