

# ParaDiag preconditioners for nonlinear and variable-coefficient problems

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ParaDiag-II algorithms solve the all-at-once system using a Krylov method preconditioned with an alpha-circulant approximation of the Jacobian which can be solved in parallel via block-diagonalisation in time.

For constant coefficient problems the convergence rate is extremely good. However, for variable coefficient problems the preconditioner must be constructed from constant coefficients to maintain diagonalisability. The convergence deteriorates for longer time intervals, but analysis of this behaviour is currently limited.

In the first part of this talk I will present the asQ library, which enables rapid and flexible prototyping of ParaDiag methods for finite element models. Results for a suite of hyperbolic and oscillatory atmospheric test cases show excellent speedups for constant coefficient problems. The performance is more modest for nonlinear problems, although the speedup is still very competitive with the state of the art.

In the second part of the talk, I will present ParaDiag convergence estimates for variable coefficient problems, and the related case where the coefficients are constant but are inexact in the preconditioner.

I will discuss the convergence estimates in relation to previous results and compare to numerical results for both parabolic and hyperbolic problems.