Dissertation Defense

Augmented Lagrangian-based Preconditioners for the Incompressible Navier-Stokes Equations

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Abstract: We analyze different variants of the augmented Lagrangian-based block triangular preconditioners for the incompressible Navier–Stokes equations in two and three space dimensions. Both steady and unsteady problems are considered. The preconditioners are used to accelerate the convergence of the Generalized Minimal Residual (GMRES) method applied to both stable and stabilized finite element and MAC discretizations of the linearized problem. We study the eigenvalues of the preconditioned matrices obtained from Picard linearization, and we devise a simple and effective method for the choice of the augmentation parameter based on Fourier analysis. Numerical experiments on a wide range of model problems demonstrate the robustness of these preconditioners, yielding fast convergence independent of mesh size and only mildly dependent on viscosity on both uniform and stretched grids. Good results are also obtained on linear systems arising from Newton linearization. We also show that performing inexact preconditioner solves with an algebraic multigrid algorithm results in excellent scalability. Comparisons of the modified augmented Lagrangian preconditioners with other state-of-the-art techniques show the competitiveness of our approach. Implementation on parallel architectures is also considered.

Friday, June 3, 2011, 4:00 pm
Mathematics and Science Center: W301

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