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Block Preconditioners for the Incompressible Navier-Stokes Equations

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We consider a preconditioner derived from a block factorization of the coefficient matrix that is generated in a Newton nonlinear iteration for the incompressible Navier-Stokes equations. This preconditioner is based on the approximation of the Schur complement operator using a technique proposed by Kay, Loghin, and Wathen and Silvester, Elman, Kay, and Wathen. It is derived using subsidiary computations (solutions of pressure Poisson and convection–diffusion–like subproblems) that are significantly easier to solve than the entire coupled system. We discuss a computational study performed using MPSalsa, a stabilized finite element code, in which parallel versions of these preconditioners are compared with a one-level overlapping Schwarz domain decomposition preconditioner. Our results show nearly ideal convergence rates for a wide range of Reynolds numbers on two-dimensional problems with both enclosed and in/out flow boundary conditions on both structured and unstructured meshes.