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Preconditioning Techniques for the Navier-Stokes Equations in Rotation Form

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We consider preconditioned iterative methods applied to discretizations of the Navier-Stokes equations in 2D and 3D bounded domains. Both unsteady and steady flows are considered. The equations are linearized by Picard iteration. We make use of the rotation form of the momentum equations, which has several advantages from the linear algebra point of view.

We focus on two classes of preconditioners for the resulting nonsymmetric saddle point problems, namely, block triangular preconditioners and some variants of the Hermitian/Skew-Hermitian splitting (HSS) preconditioner. Both types of preconditioners have comparable cost per iteration, and make use of (standard) fast solvers for elliptic scalar PDEs (convection-diffusion and Poisson-type).

We compare the performance of both types of preconditioners with regard to the mesh size, the Reynolds number, the time step, and other problem parameters. Our experiments indicate that fast convergence independent of problem parameters is achieved in many cases. We include comparing experiments for both the rotation form and convection diffusion form of the Navier-Stokes equations the nonlinear iteration.

This is joint work with Prof. Michele Benzi.