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Knoll, D.A.; Rider, W.J.

A multigrid preconditioned Newton-Krylov method.

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The authors consider the realization of Newton's method for the numerical solution of discretized boundary value problems for nonlinear partial differential equations (like the incompressible Navier-Stokes equations). The proposal is to use (on a sequence of grids) a Krylov-method (GMRES) for the solution of the linear equations arising from the Newton method in a way which avoids the formation of the Jacobi matrix, and to precondition these linear equations using a crude approximation of the Jacobi matrix on the coarse grids. The authors experimentally show that this preconditioning limits the growth of the number of Krylov iterations per Newton iterations, and that, in case of a diffusion-convection problem, a pure diffusion preconditioning works, or for a high-order approximation of such a problem, a low-order preconditioning is efficient in the sense that the convergence rates of inexact Newton methods are preserved. Their numerical examples include 1D and 2D Burgers equations and 2D Navier-Stokes equations and show that the approach is better than single-grid preconditioning or the classical Newton method with multigrid solution of the linear equations. What becomes not clear is a comparison with the full approximation scheme of *A. Brandt* [Math. Comput. 31, 333-390 (1977; Zbl 0373.65054)], but the proposed method seems to be competitive.

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Keywords: Newton-Krylov methods; multigrid preconditioning; nonlinear partial differential equations; incompressible Navier-Stokes equations; GMRES; diffusion-convection problem; convergence; numerical examples; Burgers equations
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