Reading and Thinking

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FIELD-SPLIT PRECONDITIONED INEXACT NEWTON ALGORITHMS*

LULU LIU† AND DAVID E. KEYES†

Abstract. The multiplicative Schwarz preconditioned inexact Newton (MSPIN) algorithm is presented as a complement to additive Schwarz preconditioned inexact Newton (ASPIN). At an algebraic level, ASPIN and MSPIN are variants of the same strategy to improve the convergence of systems with unbalanced nonlinearities; however, they have natural complementarity in practice. MSPIN is naturally based on partitioning of degrees of freedom in a nonlinear PDE system by field type rather than by subdomain, where a modest factor of concurrency can be sacrificed for physically motivated convergence robustness. ASPIN, originally introduced for decompositions into subdomains, is natural for high concurrency and reduction of global synchronization. We consider both types of inexact Newton algorithms in the field-split context, and we augment the classical convergence theory of ASPIN for the multiplicative case. Numerical experiments show that MSPIN can be significantly more robust than Newton methods based on global linearizations, and that MSPIN can be more robust than ASPIN and maintain fast convergence even for challenging problems, such as high Reynolds number Navier–Stokes equations.

Key words. nonlinear equations, nonlinear preconditioning, field splitting, Newton method, Navier–Stokes equations

AMS subject classifications. 65H10, 65H20, 65N22, 65N55

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- Is your application a nonlinear problem?
- How did you handle nonlinearity?
- Do you think divide-and-conquer will work for nonlinear problems? Why?
- Do you think multilevel algorithms will work for nonlinear problems? Why?
- What is your first choice to handle nonlinear problems now?