Dissertation Defense

Numerical Analysis of Mixed Formulations for Bingham Fluids

Alexis Aposporidis
Emory University

Abstract: Visco-plastic materials have been attracting a great amount of attention among researchers in the study of fluid flow due to their widespread presence in various fields of science. However, the efficient solution of the nonlinear partial differential equations modelling their flow poses many challenges. From a mathematical point of view, the major difficulty associated with solving these equations is the presence of singularities in (a priori unknown) parts of the domain. This "irregularity" often reflects in a slow convergence of numerical solvers. In this presentation we consider an augmented formulation of the Bingham visco-plastic flow which is aimed at circumventing the singularity of the equations. We present a nonlinear solver based on this formulation and compare its performance to other common techniques for solving the Bingham flow, indicating superior convergence properties of the solver based on the augmented formulation. Upon linearization and discretization, a sequence of linear systems is obtained which are in general very large and sparse. For the efficient solution of these linear systems we present a nonlinear geometric multilevel technique which is used to precondition a flexible Krylov subspace method. We conclude by presenting some applications of this work to problems in hemodynamics.

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