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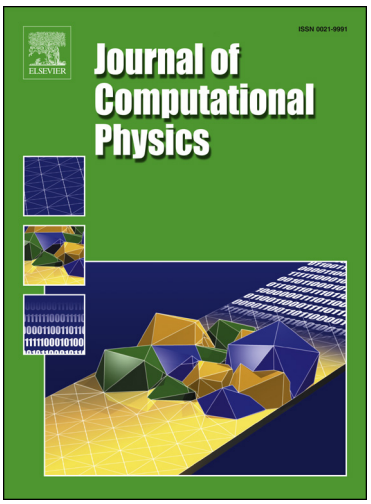

Energy-based operator splitting approach for the time discretization of coupled systems of partial and ordinary differential equations for fluid flows: The Stokes case

Lucia Carichino, Giovanna Guidoboni, Marcela Szopos

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Energy-based operator splitting approach for the time discretization of coupled systems of partial and ordinary differential equations for fluid flows: the Stokes case

Lucia Carichino[a], Giovanna Guidoboni[b], Marcela Szopos[c,*]

[a] *Department of Mathematical Sciences, Worcester Polytechnic Institute, 100 Institute Rd, Worcester, MA 01609, USA*
[b] *Department of Electrical Engineering and Computer Science, University of Missouri, 201 Naka Hall, Columbia, 65211, MO, USA*
[c] *Université de Strasbourg, CNRS, IRMA UMR 7501, F-67000 Strasbourg, France*

Abstract

The goal of this work is to develop a novel splitting approach for the numerical solution of multiscale problems involving the coupling between Stokes equations and ODE systems, as often encountered in blood flow modeling applications. The proposed algorithm is based on a semi-discretization in time based on operator splitting, whose design is guided by the rationale of ensuring that the physical energy balance is maintained at the discrete level. As a result, unconditional stability with respect to the time step choice is ensured by the implicit treatment of interface conditions within the Stokes substeps, whereas the coupling between Stokes and ODE substeps is enforced via appropriate initial conditions for each substep. Notably, unconditional stability is attained without the need of subiterating between Stokes and ODE substeps. Stability and convergence properties of the proposed algorithm are tested on three specific examples for which analytical solutions are derived.

Keywords: multiscale fluid flow, operator splitting, partial and ordinary differential equations, blood flow simulations
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*Corresponding author
Email address: szopos@math.unistra.fr (Marcela Szopos)