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An Unconditionally Energy-Stable Scheme for Incompressible Navier-Stokes Equations with Periodically Updated Coefficient Matrix[1]

SUCHUAN DONG, Purdue University — We present an unconditionally energy-stable scheme for simulating incompressible flows based on the generalized Positive Auxiliary Variable (gPAV) framework. The nonlinear term is reformulated into the form of a linear term plus a correction term, where the correction term is put under control by an auxiliary variable. The scheme incorporates a pressure-correction type strategy into the gPAV procedure, and it satisfies a discrete unconditional energy stability property. Upon discretization, the pressure linear system involves a constant coefficient matrix that can be pre-computed. The velocity linear system involves a coefficient matrix that is updated periodically, once every k_0 time steps, where k_0 is a user-specified integer. The auxiliary variable, being a scalar-valued number, is computed by a well-defined explicit formula, which guarantees the positivity of its computed values. The proposed method produces accurate simulation results at large or fairly large time step sizes for the incompressible Navier-Stokes equations. The impact of the periodic coefficient-matrix update on the overall cost of the method is observed to be small in typical numerical simulations. Several flow problems will be simulated to demonstrate the accuracy and performance of this method.

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