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A Hierarchical Iterative Solver and Fractional Timestepping Schemes for the Navier-Stokes Equations

We present in this work an iterative method for the solution of the incompressible Navier-Stokes equations. The method was first introduced in El maliki and Guenette [1]. A second order Taylor-Hood (P2-P1) element is used for the space discretization where the quadratic velocity is expressed using a hierarchical basis. A second-order backward finite difference scheme is used for the time-derivative. The convection term is linearized using a second order extrapolation method. The overall method is therefore second order in both space and time. The linear system at each time step takes some special form where the proposed iterative method exploits this decomposition and can be parallelized in a very efficient way. The method performs very well even on anisotropic meshes presenting very elongated elements. The method is then applied to compute the three-dimensional flow in a stenosis and in a 2 to 1 sudden expansion. In both cases, we show that there is a symmetry breakup for steady solutions when the Reynolds number is increased. Comparisons will be made with some variants of the Chorin-Temam fractional timestepping scheme.