Analysis of fully discrete finite element methods for 2D Navier-Stokes
equations with critical initial data
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An error estimate is presented for a fully discrete semi-implicit finite element method for the two-dimensional Navier-Stokes equations with L^2 initial data in convex polygonal domains, without extra regularity assumptions or grid-ratio conditions, by utilizing the smoothing properties of the Navier-Stokes equations, an appropriate duality argument, and the smallness of the numerical solution in the discrete $L^2(0, t_m; H^1)$ norm when t_m is smaller than some constant.