YVES BOURGAULT, Université d'Ottawa
Linearly-Implicit Backward Difference Formulas for Navier-Stokes Equations

We propose a linearly-implicit method (called LBDFT) to solve the incompressible Navier-Stokes equations. Linearly-implicit methods have an algorithmic complexity that lies between fully-implicit and semi-implicit time-stepping schemes. In LBDFT, the nonlinear advection in the Navier-Stokes equations is split into three linear terms using a Taylor series expansion. One term is taken explicitly and the other two are updated with the linear diffusion term at each time step. Linearly-implicit methods were also proposed in [Garcia-Archilla & Novo, IMA J Num Analysis, 2022][Wang et als, CAM, 2023], in this case based on extrapolation formulae as for semi-implicit methods. These methods are then compared with various fully-implicit and semi-implicit time-stepping methods in terms of accuracy, stability, computing time and ability to compute various flows. We first use two standard test cases to assess the methods. We observed that linearly-implicit methods are more CPU efficient compared to fully-implicit BDF, both at second- and third-order of accuracy. Our third test case explores the ability of the methods to compute steady flows at high Reynolds numbers. LBDFT was able to compute steady cavity flows for Reynolds up to 500,000. Our last test case explores unsteady flows at large Reynolds numbers. It was observed that the linearly-implicit methods allow significantly larger critical time step (40-50 times larger) compared to the semi-implicit methods, the latters needing a stabilization term to maintain their stability. This article is co-authored with Kak Choon Loy, Faculty of Computer Science and Mathematics, Universiti Malaysia Terengganu, Malaysia.