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Investigation of flow-induced numerical instability in a mixed semi-implicit, implicit leapfrog time discretization[1] JACOB KING, SCOTT KRUGER, Tech-X Corporation — Flow can impact the stability and nonlinear evolution of range of instabilities (e.g. RWMs, NTMs, sawteeth, locked modes, PBMs, and high-k turbulence) and thus robust numerical algorithms for simulations with flow are essential. Recent simulations of DIII-D QH-mode [King et al., Phys. Plasmas and Nucl. Fus. 2017] with flow have been restricted to smaller time-step sizes than corresponding computations without flow. These computations use a mixed semi-implicit, implicit leapfrog time discretization as implemented in the NIMROD code [Sovinec et al., JCP 2004]. While prior analysis has shown that this algorithm is unconditionally stable with respect to the effect of large flows on the MHD waves in slab geometry [Sovinec et al., JCP 2010], our present Von Neumann stability analysis shows that a flow-induced numerical instability may arise when ad-hoc cylindrical curvature is included. Computations with the NIMROD code in cylindrical geometry with rigid rotation and without free-energy drive from current or pressure gradients qualitatively confirm this analysis. We explore potential methods to circumvent this flow-induced numerical instability such as using a semi-Lagrangian formulation instead of time-centered implicit advection and/or modification to the semi-implicit operator.

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