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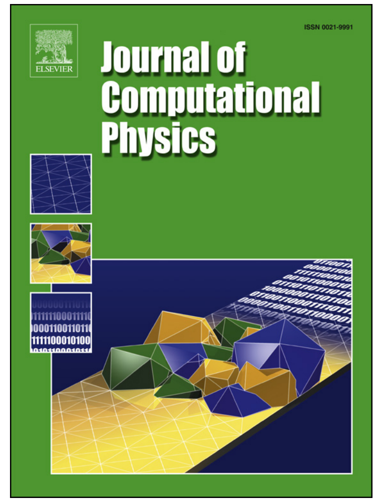


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# Efficient stabilization and acceleration of numerical simulation of fluid flows by residual recombination

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**Abstract**

The study of the stability of a dynamical system described by a set of partial differential equations (PDEs) requires the computation of unstable states as the control parameter exceeds its critical threshold. Unfortunately, the discretization of the governing equations, especially for fluid dynamic applications, often leads to very large discrete systems. As a consequence, matrix based methods, like for example the Newton-Raphson algorithm coupled with a direct inversion of the Jacobian matrix, lead to computational costs too large in terms of both memory and execution time.

We present a novel iterative algorithm, inspired by Krylov-subspace methods, which is able to compute unstable steady states and/or accelerate the convergence to stable configurations. Our new algorithm is based on the minimization of the residual norm at each iteration step with a projection basis updated at each iteration rather than at periodic restarts like in the classical GMRES method. The algorithm is able to stabilize any dynamical system without increasing the computational time of the original numerical procedure used to solve the governing equations. Moreover, it can be easily inserted into a pre-existing relaxation (integration) procedure with a call to a single *black-box* subroutine.

The procedure is discussed for problems of different sizes, ranging from a small two-dimensional system to a large three-dimensional problem involving the Navier-Stokes equations. We also show that the proposed algorithm is able to improve the convergence of existing iterative schemes. In particular, the procedure is applied to the subcritical flow inside a lid-driven cavity. We also discuss the application of `Boostconv` to compute the unstable steady flow past a fixed circular cylinder (2D) and boundary-layer flow over a hemi-