A comparison of Explicit, Implicit, and IMEX time integration schemes for the two-dimensional Burgers' System

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Abstract

Time integration of partial differential equations can be achieved by several methods, usually categorized into implicit or explicit schemes. Implicit schemes can generate stable approaches with no restrictions imposed on space and time discretizations, but can also lead to computationally expensive systems of non-linear equations. Explicit schemes, on the other hand, are easily implemented, but are only conditionally stable if they follow the Lax equivalence theorem. This often restricts explicit simulations to very small time steps. A more recent approach is a combination of both methods, resulting in the so called IMEX (Implicit-Explicit) schemes. This class of methods was designed to solve equations with fast and slow time-scales in such a way that the slow terms can be solved explicitly, while the slow terms are solved implicitly. This results in a combination of different schemes that optimizes processing time by avoiding unnecessarily small time steps for the fast terms. Here the finite difference approach is used to solve a two-dimensional, viscous Burgers' system of equations through each of the aforementioned time integration schemes (implicit, explicit, IMEX) in a comparative study of their properties. Burgers' equation is a widely used model in computational fluid dynamics, with known analytical solution. Numerical results are evaluated against the analytical solution, and the processing time for the different schemes can be compared.

Keywords: Time Integration, Finite Difference, IMEX Schemes, Burgers' Equation.

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