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ADAPTIVE COMPUTATION OF TURBULENT COMPRESSIBLE FLOW USING A GENERAL GALERKIN METHOD

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ABSTRACT

Simulation of turbulent fluid flow is the major challenge of computational fluid dynamics, with an incomplete mathematical foundation of the underlying Navier-Stokes equations, and insufficient computational resources for full resolution of all length scales of the flow field even with the most powerfull supercomputers of today or tomorrow. The standard computational approaches, such as LES or RANS, are based on seeking modified equations for the mean value of the flow field which are closed using turbulence (subgrid) modeling, see e.g. [1].

In [2] an alterative approach is proposed for incompressible flow based on the new mathematical concepts of ϵ-weak solutions and weak uniqueness. No subgrid/turbulence modeling is used, but instead approximate weak solutions are computed using a stabilized finite element method, which we refer to as a General Galerkin (G2) method, with adaptive mesh refinement with respect to a chosen output of interest, where the adaptive algorithm is based on a posteriori error estimation using duality techniques.

Stabilized finite element methods for compressible flow is well developed, see e.g. [3] for an overview of SUPG methods, and adaptive finite element methods for laminar compressible flow have earlier been investigated e.g. in [4,5]. In this paper we present an extension of the G2 framework to turbulent compressible flow, following the corresponding extension to turbulent incompressible flow in [2]. We use a finite element method with continuous linear approximation in space and time, and with streamline diffusion stabilization together with residual based shock-capturing, which results in a stable method with exact global conservation of mass, momentum and energy.

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