TACKLING TURBULENT FLOWS WITH A THREE–LEVEL FINITE ELEMENT METHOD

Volker Gravemeier, Wolfgang A. Wall and Ekkehard Ramm

Institute of Structural Mechanics
University of Stuttgart
Pfaffenwaldring 7, D–70550 Stuttgart, Germany
{gravem, wall, eramm}@statik.uni–stuttgart.de

The numerical simulation of incompressible flows governed by the Navier–Stokes equations requires to deal with subgrid phenomena. Particularly in turbulent flows the scale spectra are notably widened and need to be handled adequately to get a reasonable numerical solution. Based on the variational multiscale method [3] we have developed and presented a three–level finite element method in [1] and [2]. The core feature of this method consists in the separation of three different scale ranges: large (resolved) scales, small (resolved) scales and unresolved scales. Any of these scale groups is treated differently. For solving the large scales we apply a standard finite element space. The use of residual–free bubbles in approximate form with the help of elementwise submeshes is our means for dealing with the small scales. The unresolved scales are incorporated by way of their dissipative effect onto the resolved scales with a dynamic procedure based on elementwise sub–submeshes. This method has been demonstrated to work fine in simulating numerically several quite different laminar flow situations.

In this work we would like to present our first steps in applying this methodology to turbulent flow situations. In particular, we are interested in wall–bounded shear flows. Turbulent channel flow is surely the simplest and most widespread example for such a flow. It has been investigated for a low Reynolds number in detail by Kim et al. [5] using a direct numerical simulation (DNS). See also [6] for some important aspects of DNS. In order to make available an initial data basis, we apply a stabilized finite element method with a sufficient spatial discretization for a DNS. Afterwards, our three–level method will be applied in the sense of a large–eddy simulation [7] with notedly coarser spatial discretizations to the same flow situation. These results will be compared with the DNS data basis. Some general considerations concerning the suitability of the variational multiscale method as a basic concept for large–eddy simulations of turbulent flows were pointed out in [4].

References

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