A variational multiscale method for turbulent flow simulations with an adaptive choice of the large scale space

Adela Kindl[1] Volker John[2]

Variational Multiscale (VMS) methods are a rather new approach in simulating turbulent flows. The basic idea of VMS methods, in contrast to traditional LES, is the use of variational projections instead of filtering for the scale decomposition, thus eliminating several difficulties of the traditional LES, e.g. commutation errors.

We consider a three scale decomposition of the flow: large (resolved) scales, resolved small scales, and (small) unresolved scales. Assuming that the direct influence of the unresolved scales onto the large scales is negligible, and thus the direct influence of the unresolved scales is confined to the resolved small scales, the influence of the unresolved scales onto the resolved small scales is modeled with a turbulence model. In the context of finite element discretizations, the parameters of a VMS method are the finite element spaces used to define the scale decomposition and the turbulence model acting directly only on the small scales. Regarding the turbulence model, the parameter in the additional viscous term added to the small scale equation is generally chosen to be an eddy viscosity model of Smagorinsky type. Regarding the spaces standard finite element spaces are considered for all resolved scales and the separation of the large and the resolved small scales is achieved through an additional large scale space.

We will present and discuss an adaptive choice of the large scale space, allowing different polynomial degrees on different mesh cells. This so called adaptive large scale projection-based method (ALS-VMS), aims at avoiding the too large diffusivity of the Smagorinsky model in regions with little turbulence, and this through an appropriate choice of the large scale space.

[1] Universität des Saarlandes, FR 6.1 - Mathematik, Postfach 15 11 10, 66041 Saarbrücken, Germany, adela@c-kindl.de

[2] Universität des Saarlandes, FR 6.1 - Mathematik, Postfach 15 11 10, 66041 Saarbrücken, Germany, john@math.uni-sb.de