

Courses 2014-15

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STABILIZED AND VARIATIONAL MULTI-SCALE METHODS. APPLICATION TO INCOMPRESSIBLE FLOWS AND TURBULENCE MODELLING

Abstract

This course is focused on the solution of incompressible flow equations by means of Variational Multi-Scale and Stabilized finite element methods, with special emphasis on turbulent flows. We motivate the derivation of the methods, perform their numerical analysis (stability, convergence and error analysis) and apply them to the effective solution of relevant flows.

Program

1. Abstract VMS setting. Application to convection-diffusion equations. Derivation of stabilized methods: SUPG, OSS, penalty-stabilized.
2. VMS methods with spectral approximation of sub-grid scales. Application to the convection-diffusion equations. Numerical experiments.
3. VMS and stabilized methods for linear incompressible flow equations. Numerical analysis: Underlying inf-sup condition. Stability, convergence and error analysis.
4. VMS and stabilized methods for Navier-Stokes equations. Steady and unsteady flows. Stability, convergence and error analysis. Numerical experiments.
5. A projection-based VMS turbulence model. Statement of model. Stability, convergence and error analysis. Numerical experiments.

Bibliography

- Chacón Rebollo, T., Lewandowski, R.: *Mathematical and Numerical Foundations of Turbulence Models and Applications*. Birkhauser, 2014.
- Codina, R., Soto, O.: Approximation of the incompressible Navier-Stokes equations using orthogonal-subscale stabilization and pressure segregation on anisotropic finite element meshes. *Comput. Methods Appl. Mech. Engrg.* Vol. 193, pp. 1403-1419 (2004).
- Hughes, T. J. R., Feij'oo, G., Mazzei, L., Quincy, J-B: The variational multiscale method paradigm for computational mechanics. *Comp. Meth. Appl. Mech. Engrg.*, Vol. 166 (1-2), pp. 3-24 (1998).
- Erwin Stein, René de Borst, Thomas J.R. Hughes, *Encyclopedia of Computational Mechanics, Volume 3: Fluids*, Wiley, 2004.