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# Editorial

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## SUMMARY

This special issue contains selected high-quality papers from the invited lectures of the *Fourth International Symposium on Finite Volumes for Complex Applications*—Problems and Perspectives (FVCA), which was sponsored by Marrakech University of Science and Technology in Morocco and held in the university on July 4–8, 2005. The FVCA symposia series aims to provide an international and privileged forum for the exchange and profitable discussions bringing together mathematicians, physicists and engineers concerned with finite volume techniques in both theory and practice. Indeed, the finite volume method is nowadays adopted by a broad base of the scientific community including those concerned with the use of numerical simulations in the resolution of complex physical problems in industry, civil engineering and the environmental.

This special issue contains six papers based on those that were presented as invited lectures at FVCA4. Particular attention is focused on convergence, error analysis and new fields of application. Copyright © 2009 John Wiley & Sons, Ltd.

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KEY WORDS: finite volume; approximation; convergence; error analysis; *a posteriori* error analysis; mesh refinement; mesh de-refinement; mesh adaptation; discontinuous Galerkin; elliptic equations; parabolic equations; hyperbolic conservation laws; Navier–Stokes equations; Boussinesq hypothesis; operator splitting; two-phase flows; unsteady flows; convection–diffusion; heat equation; semiconductor devices; drift–diffusion; energy transport

Chainais-Hillairet's [1] talk was devoted to the drift–diffusion and the energy transport models appearing in the modelling of semiconductor devices. The main difficulty arising in the approximation of the energy transport model using finite volume schemes is the discretization of the Joule heating term in the equation for the density of energy. Following some recent ideas by K. Domelevo and P. Omnes for the discretization of the Laplace equation on almost general meshes, Chainais-Hillairet explains the construction of a finite volume approximation of the

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two-dimensional drift-diffusion and energy transport models. These schemes still hold on almost general meshes. Finally, results are presented for numerical simulations of semiconductor devices.

Chenier [2] describes a collocated finite volume scheme that was recently developed for the numerical simulation of the incompressible Navier–Stokes equations on unstructured meshes, in 2 or 3 space dimensions. He recalls its convergence in the case of the linear Stokes equations, and proves a convergence theorem for the case of the Navier–Stokes equations under the Boussinesq hypothesis. He then presents several numerical studies. A comparison between a cluster-type stabilization technique and the more classical Brezzi–Pitkaranta method is performed, the numerical convergence properties are presented on both analytical solutions and benchmark problems and the scheme is applied to the study of natural convection between two eccentric cylinders.

Amaziane [3] describes work on the recent progress of *a posteriori* error analysis of a vertex-centred finite volume scheme for elliptic and parabolic equations in the energy norm. The global error between the solution of the exact equation and the solution of the discrete problem is bounded, in the energy norm, by the Hilbertian sum of the error indicators, while each indicator is bounded by the local error. The indicators are local and related to the space or time error, completely computable and are used in the refinement or de-refinement of the mesh.

Hérard [4] devoted his contribution to a brief review of some problems arising in the NEPTUNE project, whose main objective consists of creating a new generation of two-phase flow codes covering the whole range of modelling scales for nuclear power plants. Focus is given on multiphase flow modelling and on the unsteady coupling of existing codes. Some recent results are presented and a few open problems are discussed.

The contribution of Chertock [5] was motivated by the fact that computing solutions of the convection–diffusion equations, especially in the convection-dominated case, is an important and challenging problem that requires development of fast, reliable numerical methods. She proposes a second-order fast explicit operator splitting (FEOS) method based on the Strang splitting. The main idea of the method is to solve the parabolic problem via a discretization of the formula for the exact solution of the heat equation, which is realized using a conservative and accurate quadrature formula. The hyperbolic problem is solved by a second-order finite-volume Godunov-type scheme. The FEOS method is applied to one- and two-dimensional systems modelling two-phase multicomponent flow in porous media. The results demonstrate that the method achieves a remarkable resolution and accuracy in a very efficient manner, that is, when only a few splitting steps are performed.

Ohlberger [6] presents a contribution in which he gives an overview on recent progress in obtaining *a posteriori* error control for finite volume and discontinuous Galerkin approximations of nonlinear hyperbolic conservation laws. The theory is based on the celebrated doubling of variables technique introduced by Kruzkov. *A posteriori* error control is of particular importance as it can be used for designing efficient grid adaptive schemes. The derivation of such adaptive methods is discussed and numerical experiments are given.

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