This volume contains the abstracts of the papers presented at the International Conference on Numerical Methods for Hyperbolic Equations: Theory and Applications held in the Faculty of Mathematics of the University of Santiago de Compostela, Spain, from 4th to 8th July 2011. The conference was organized to honour Professor Toro in the month of his 65th birthday. We think that all contributions are a valuable state of the art of the most recent research in the topic of numerical methods for hyperbolic equations providing the reader with the latest developments concerning the mathematical aspects and the applications of this active field of mathematics.
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for Hyperbolic Equations
Numerical Methods for Hyperbolic Equations
Theory and Applications
An International Conference to Honour Professor E. F. Toro
Santiago de Compostela, July, 4th-8th 2011
BOOK OF ABSTRACTS

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We would like to address our warmest thanks to the invited speakers: Juan Cheng (Institute of Applied Physics and Computational Mathematics, China), Frédéric Coquel (UPMC Paris 06, CNRS, France), James Glimm (University of Stony Brook, USA), José María Ibañez (Department of Astronomy and Astrophysics University of Valencia, Spain), Philippe LeFloch (University of Paris 6, France), Amable Liñan (Polytechnical University of Madrid, Spain), Alfio Quarteroni (Swiss Federal Institute of Technology, Lausanne, Switzerland), Philip L. Roe (University of Michigan, USA), Eleuterio Francisco Toro (University of Trento, Italy) and Chi-Wang Shu (Brown University, USA).

More than 70 abstracts were accepted for presentation at the following minisymposia:

- Recent advances in the numerical computation of environmental conservation laws with source terms.
- Multiphase flow and porous media.
- Numerical methods in astrophysics.
- Seismology and geophysics modelling.
- Finite volume and discontinuous Galerkin schemes for stiff source term problems.
- Methods and models for biomedical problems.

and parallel sessions:

- High order methods for hyperbolic conservation laws.
- Numerical methods for reactive flows and acoustics.
- Shallow water flows.

We think that all contributions are a valuable state of the art of the most recent research in the topic of numerical methods for hyperbolic equations providing the reader with the latest developments concerning the mathematical aspects and the applications of this active field of mathematics.

We would like to thank all the participants for the attendance and for their valuable contributions. Special thanks to the minisymposium organizers who made a large contribution to the conference.
Finite Volume Method for Three-Dimensional Particle-Laden Free-Surface Flow†

Patricio Bohorquez†

Keywords: Polyhedral mesh, Volume of Fluid, Finite Volume Method, Thin Film Flow, Equilibrium Theory of Dense Suspension.

Minisymposia: Multiphase flow and porous media

Parallel Session: Shallow water flows

Abstract We present a Finite Volume Method (FVM) for three-dimensional, incompressible, free-surface flow in the presence of non-cohesive, uni-modal, sediment particles near equilibrium. The physical model is based on the mixture (or drift-flux) theory [1]. The continuity equations of the water, sediment and air phases are reformulated in terms of the mixture volumetric velocity $\vec{u}$,

$$\nabla \cdot \vec{u} = 0, \quad (1)$$

resulting in two scalar transport equations as

$$\frac{\partial \phi}{\partial t} + \nabla \cdot (\phi \vec{u}) + \nabla \cdot [\phi(1-\phi)\vec{u}_\delta] = 0, \quad \phi = \beta, \gamma \quad (2)$$

where $t$ is time, $\vec{u}_\delta$ denotes the slip velocity, $\beta$ is the sediment-volumetric concentration and $\gamma$ is the phase indicator function employed to capture the free surface. Equation (3) is solved by means of an explicit numerical scheme designed for the multi-dimensional advection equation [2]. The bulk momentum equation is formulated under the assumption of near equilibrium between water and sediment, i.e. $|\vec{u}_\beta| \ll |\vec{u}|$. Under this assumption, the mixture momentum equation reads [3]

$$\frac{\partial \rho \vec{v}}{\partial t} + \nabla \cdot (\rho \vec{v} \vec{v}) = -\nabla p + \nabla \cdot \vec{F} - \vec{g} \cdot \vec{x} \nabla \rho, \quad (3)$$

where $\rho$ is the mixture density, $\vec{v} := \vec{v}(\vec{u}, \vec{u}_\phi)$ is the mixture mass velocity, $\vec{g}$ is the acceleration due to gravity, and $\vec{F}$ is the generalised stress tensor that accounts for the viscous stress tensor, the diffusion stresses due to the relative motion between phases and the non-isotropic part of the sediment stress tensor. The model reveals that the isotropic part of the bulk stress tensor, i.e. the mixture pressure $p$, plays the same role as for a single incompressible flow. Consequently, (1)–(3) are discretised and assembled into a block system using a Schur complement formulation [4].

†This work has been supported by the Spanish MCyT, Junta de Andalucía and European funds under Projects# DPI2008-06624-C02 and P07-TEP02693
We compare numerical results obtained both in structure and polyhedral meshes for two physical problems: vertical settlers in the presence of free surface [5] and particle-laden flows down a steep inclined plane [6]. With these examples, we show the capability of the numerical scheme to capture discontinuities in $\phi$, see figure 1, and to obtain the pressure distribution and the three-dimensional velocity profile. Finally, we also assess the mesh topology influence on the numerical results.

![Figure 1: Numerical solution (left) for the volumetric concentration of sediment $\beta(z,t)$ in the experiments (right) by Snabre et al. [5].](image)

**References**


Numerical Methods for Hyperbolic Equations: Theory and Applications. An international conference to honour Professor E.F. Toro
University of Santiago de Compostela, 4-8 july 2011, Spain

Numerical simulation of a bubble rising in still liquids: determination of the instability transition modes†

J. C. Cano-Lozano, P. Bohorquez, C. Martínez-Bazán

Keywords: Bubble, Hydrodynamic Stability, Volume of Fluid, Finite Volume Method.

Minisymposia: Multiphase flow and porous media

Abstract: In this work, we have investigated numerically the transition from straight to zigzag motion during the rise of a single gas bubble of diameter $D$ in a pure-clear stagnant liquid [1], for the limiting case $\rho_g/\rho_l \ll 1$ and $\mu_g/\mu_l \ll 1$, where $\rho$ is density, $\mu$ is dynamic viscosity, and subindices $g$ and $l$ denote gas and liquid phases, respectively. The transition is determined in terms of the Reynolds, $Re = \rho_l g^{1/2} D^{3/2}/\mu_l$, and Bond, $Bo = \rho_l g D^2/\sigma$, numbers as set of nondimensional, independent parameters governing the flow dynamics [2], in which $g$ is the acceleration due to gravity and $\sigma$ is the surface tension. Subsequently, the neutral curve for the onset of zigzag motion is characterized in the $(Re, Bo)$-plane.

This type of flow has been previously studied numerically and experimentally [1, 2, 3]. From the numerical point of view, the terminal velocity and bubble shape are usually computed under the axisymmetric hypothesis, e.g. [2], though the real flow is both three-dimensional and unsteady. On the experimental side, e.g. [1], available data for the neutral curve cover a limited part of the $(Re, Bo)$ diagram because of the intrinsic difficulties to the current problem, see dashed line in figure 1(a). Although the neutral curve has been already determined considering a spheroidal shape for the bubble [3], its precise description is still an unresolved problem. Thus, in this work we characterise accurately the above mentioned transition combining several second-order finite volume methods, which have been implemented in open source software, discussing the advantages of each one. We show that the combination of Godunov momentum advection scheme and adaptive quadtree mesh refinement, available in Gerris flow solver [4], performs better than schemes implemented in the interFoam multiphase solver in OpenFOAM. Consequently, the axisymmetric basic flow is characterised by means of Gerris flow solver, see figure 1(b), and the evolution of the bubble shape, terminal velocity, pressure and velocity fields described as functions of $Re$ and $Bo$ in the vicinity of the neutral curve. The stability property of the background flow is subsequently determined by means of three-dimensional numerical simulations [5], showing the loss of the flow axisymmetry and the developing of two counter-rotating vortices, as illustrated in figure 1(c).

†This work has been supported by the Spanish MCyT, Junta de Andalucía and European funds under Projects# DPI2008-06624-C02 and P07-TEP02693
Figure 1: (a) Stability diagram showing the experimental neutral curve [1], dashed line, and our preliminary result, blue circle. Thin solid lines depict the Morton number, $Mo = g
u_f^2 / \rho_L \sigma^3$, from $10^{-12}$ to $10^4$. (b) Axisymmetric bubble at $Re = 113.1$ and $Bo = 3.925$ simulated with Gerris flow solver. (c) Streamwise vorticity contours observed in the three-dimensional perturbed flow with axisymmetric bubble shape, corresponding with the circle depicted in (a).

References


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*Finite Volume Method for Three-Dimensional Particle-Laden Free-Surface Flow*

at the International Conference "*Numerical Methods for Hyperbolic Equations: Theory and Applications*", to honour Professor E.F. Toro in the month of his 65th birthday. The conference was held on 4-8 July 2011 at the Faculty of Mathematics, University of Santiago de Compostela, Spain.

Santiago de Compostela, July 8, 2011

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