

C U R S O S E C O N G R E S O S

**AN INTERNATIONAL CONFERENCE
TO HONOUR
PROFESSOR E. F. TORO**

BOOK OF ABSTRACTS

**Santiago de Compostela
July, 4th-8th, 2011**

Numerical Methods for Hyperbolic Equations

Theory and Applications



EDITED BY
A. Bermúdez
L. Cea
E. Vázquez-Cendón

UNIVERSIDADE
DE SANTIAGO
DE COMPOSTELA

publicacións

Numerical Methods
for Hyperbolic Equations

CURSOS E CONGRESOS DA
UNIVERSIDADE DE SANTIAGO DE COMPOSTELA
Nº 202

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

Edited by
A. BERMÚDEZ
L. CEA
E. VÁZQUEZ-CENDÓN

2011

UNIVERSIDADE DE SANTIAGO DE COMPOSTELA

Numerical methods for hyperbolic equations : theory and applications : an international conference to honor professor E. F. Toro, Santiago de Compostela, July 4-8, 2011 / edited by A Bermúdez, L. Cea, E. Vázquez-Cendón. — Santiago de Compostela : Universidade, Servizo de Publicacións e Intercambio Científico, 2011. — p. : cm. — (Cursos e congresos da Universidade de Santiago de Compostela ; 202). — D.L. . — ISBN 978-84-9887-713-7

1 Análise numérica. 2 Ecuacións hiperbólicas. I. Bermúdez de Castro, A., ed. II. Cea, L. ed. III. Vázquez-Cendón, E., ed. IV. Universidade de Santiago de Compostela. Servizo de Publicacións e Intercambio Científico, ed. V. Serie

519.6
517.956.3

© Universidade de Santiago de Compostela, 2011

Edita

Servizo de Publicacións e Intercambio Científico
Campus Vida
15782 Santiago de Compostela
www.usc.es/publicacions

ISBN 978-84-9887-713-7 (edición dixital .pdf)

Contents

Foreword	9
Invited Speakers	12
On the design of conservative, accurate and symmetrical cell-centered Lagrangian schemes in 2D cylindrical coordinates for compressible fluid flows.....	13
New Trends in Hyperbolic Problems in the Industry.....	14
Mathematical Theories of existence for 3D conservation laws and the nature of convergence in the large eddy simulation regime.	16
Numerical Relativistic Magnetohydrodynamics in Dynamical Spacetimes	17
Wpf gteqo r tguikdrg'uj qemu'cpf "o qxlpi 'rj cug"dqwpf ctkgu.....(000)	18
The initiation of detonations in reactive gases	19
Mathematical models for the cardiovascular system: analysis, numerical simulation, applications	21
Shock-capturing, past and future.....	22
The Riemann problem in computational science	23
Maximum-principle-satisfying and positivity-preserving high order discontinuous Galerkin and finite volume schemes for conservation laws.....	24
Minisymposia	26
Finite volume and discontinuous Galerkin schemes for stiff source term problems	27
Path-Conservative Schemes for Hyperbolic Source Term Problems.....	28
Entropy conservative and entropy stable schemes for nonconservative systems.....	30
A Runge-Kutta based Discontinuous Galerkin Method with Time Accurate Local Time Stepping	31
An efficient ADER scheme.....	33
A Unified Approach for High Order Finite–Volume and Discontinuous Galerkin Schemes for PDE with Stiff Source Terms	35
Accuracy enhancement of discontinuous Galerkin methods for stiff source terms	37
Novel shock-capturing schemes for Discontinuous Galerkin methods.....	39
Numerical Solution of Viscous and Thermally Conductive Gaseous Flows Via Hyperbolic Maximum Entropy Moment Closures	41
Methods and models for biomedical problems	43
A fully adaptive numerical approximation for a two-dimensional epidemic model with nonlinear cross-diffusion.....	44
Modeling and simulation of the hydrodynamics-biology coupling in a raceway.	45

A simple model of filtration and macromolecule transport through microvascular walls	47
Assessment of numerical methods for blood flow in veins.....	49
Reduced models for the Fluid-Structure Interaction problem.....	52
Multiphase flow and porous media	53
Dynamics of submerged gravitational granular flows.....	54
Finite Volume Method for Three-Dimensional Particle-Laden Free-Surface Flow	56
Numerical simulation of a bubble rising in still liquids: determination of the instability transition modes	58
Numerical simulation of three-dimensional transient variably saturated flow.....	60
An all-speed asymptotic preserving scheme for the low Mach number limit of the Euler equations.....	62
A New Scheme for Non-Classical Waves with TVB Proof for Scalar 1D-Case	64
Modelling Microbial Chemotactic Waves in Saturated Porous Media using Adaptive Mesh Refinement.	66
Numerical simulation of transport equations in Liquid Composite Molding Processes.....	68
Mathematical modeling of heat transfer during quenching process.....	70
Conservative formulation for compressible fluid flow through elastic porous media.....	72
On the coupling of compressible and incompressible fluids.....	74
Numerical methods in astrophysics	76
Numerical methods for the hyperbolic evolution equations in the Fully Constrained Formalism of Einstein equations.	77
SPH versus AMR.....	79
An Approximate Harten-Lax-van Leer Riemann Solver for Relativistic Magnetohydrodynamics.....	80
MUSTA schemes in magnetohydrodynamics and neutrino transfer: application to core-collapse supernovae and gamma-ray bursts	82
MHD-kinetic Modeling of Partially Ionized Plasma Flows: Solar Wind Interaction with the Interstellar Medium	84
ON THE RIEMANN PROBLEM IN RELATIVISTIC HD AND MHD.....	86
Recent advances in the numerical computation of environmental conservation laws with source terms	87
Asymptotic behaviour of godunov-type numerical models with mobile bed with adaptation term.	88
Finite volume discretisation of depth averaged scalar transport equations coupled to shallow water models.	90
A finite volume/duality method for Bingham viscoplastic flow	92
Anumerical model for global climate: effect of the latent heat of fusion.....	94
Residual Distribution for Shallow Water Flows	96

Modelling of Flood Problems based on a Two-Dimensional Well-Balanced Wave Propagation Algorithm with Bed Efflux /Influx Source Terms Including a Coupled Pipe Network Solver.....	98
A Large Time Step Upwind Scheme for the Shallow Water Equations with source terms.....	100
Augmented Roe’s approaches for Riemann problems including source terms: definition of stability region with application to the shallow water equations with rigid and deformable bed.....	102
Balancing source terms revisited in depth-averaged Smoothed Particle Hydrodynamics (SPH).....	104
Flooding simulations with subgrids.....	106
Seismology and geophysics modelling.....	107
Dynamics of gravitational instabilities on Earth and on Mars.....	108
Two-phase models for debris flows.....	109
Meshless methods for lava flow modeling and simulation.....	111
Finite volume schemes for balance laws on time-dependent surfaces.....	113
Finite volume schemes for nonlinear dispersive wave equations.....	115
Tsunami modelling using high order finite volume schemes on GPUs.....	116
On multilayer shallow water systems.....	118
Parallel Sessions.....	120
High Order Methods for Hyperbolic Conservtion Laws.....	121
Comparison among different high order time integration methods useful for explicit schemes.....	122
High resolution schemes: TVD region its dependence on smoothness parameter.....	124
A numerical treatment of wet/dry zones in Well-Balanced Hybrid Schemes for Shallow Water Flow.....	126
On the Analysis of a Solver for Generalized Riemann Problems by Asymptotic Expansion.....	128
CFL-Number-dependent TVD-Limiters.....	130
Arbitrary High Order Schemes for Transport Problems.....	132
An Five-Equation Model Based ALE Method for Compressible Multifluid Fluids.....	134
Efficient deterministic modelling of three-dimensional rarefied gas flows.....	136
High order stochastic finite volume methods for the numerical solution of hyperbolic equations with random initial data.....	138
Discontinuous-in-space explicit Runge-Kutta residual distribution schemes for time-dependent problems.....	140
Numerical Methods for Reactive Flows.....	142
Numerical simulation of a pulverized coal jet.....	143
Chapman-Jouguet conditions with temperature and velocity disequilibrium.....	145
Multi-phase simulation of Ammonium Nitrate Emulsion Detonations.....	147
A Flux Vector Splitting Scheme for the Euler Equations.....	149

On the use of Moving Least Squares for pressure discretization in low Mach number flows	151
Shallow Water Flows	153
Approximation of the Navier-Stokes system by multilayer models	154
Modeling of 3D phenomena in curved channels. Suitability of a 3D shallow waters approximation.	156
Porosity versus resolved approach in 2D shallow water models. Experimental validation.	158
A WENO scheme for the integral form of contravariant shallow water equations.....	160
A two-layer tidal-exchange flow.....	162
Numerical modelling of two-dimensional morphodynamics in gravel bed rivers.....	164
Poster Sessions	166
Noninvasive Monitoring of Hepatic Damage from Hepatitis C Virus Infection	167
Extension of fourthorder nonoscillatory central schemes to sediment transport equations	169
First approach to the application of operational 4DVAR Data Assimilation to the Regional Ocean Model System.....	171
Vascular network hemodynamics: Application to the study of Arteriovenous Malformations	173
Changes in buoyancy-driven instabilities by using a reaction-diffusion system.....	175
A Mean Gradient Method to Solve Shallow Flows.	177
Upwind and central schemes for nonhomogeneous hyperbolic conservation laws recognizing stationary solutions	179
Miscible Viscous Fingering on Reactive Interface	181
Discontinuous Galerkin Methods for Vlasov-Poisson system.....	182

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

A WENO scheme for the integral form of contravariant shallow water equations

F. Gallerano, G. Cannata, M. Tamburrino¹

Keywords: 2D shallow water equations, Upwind WENO scheme, integral form, contravariant formulation, generalized curvilinear coordinates, Exact Riemann Solver

Parallel Session: Shallow water flows

Abstract Many authors solve shallow water equations by using Weighted Essentially Non-Oscillatory (WENO) schemes. Flow simulations over computational domains characterized by a complex boundary can be performed by numerical integrations of the contravariant form of motion equations on a generalized curvilinear boundary conforming grid.

In numerical solutions of motion equations in contravariant formulation, two contradictions appear. The first contradiction is related to the presence of Christoffel symbols in motion equations. It is well known that numerical methods for the solution of the conservation laws in which the convective terms are expressed in non-conservative form do not guarantee the convergence to weak solutions. Consequently in the integrations of the conservation laws in whose solutions shocks are present, convective terms must be expressed in conservative form. In the contravariant formulation of motion equations, covariant derivatives give rise to Christoffel symbols. These terms are extra source terms. They come in with the variability of base vectors and do not permit the definition of convective terms in a conservation form. The second contradiction is related to the difficulty of exactly numerically satisfying the metric identities and preserve the freestream conditions. A well known geometric identity is given by the condition that a cell is closed. In a curvilinear system of reference the summation condition becomes the metric identity. If numerical approximations of the metric coefficients do not exactly satisfy the above mentioned identities, the numerical approximations of derivatives of uniform physical quantities do not vanish and freestream conditions are not preserved.

The original contribution of this work is the definition of a new Upwind WENO scheme for the solution of the 2D shallow water equations expressed directly in contravariant formulation. An element of novelty presented in this paper regards the definition of a formal integral expression of the shallow water equations in contravariant formulation. The depth-integrated motion equations (in contravariant form) are integrated on an arbitrary surface and are resolved in the direction identified by a constant parallel field of unit vectors. In this way we present an integral form of the contravariant shallow-water equations in which Christoffel symbols are avoided. In order to correct the effects produced by the spurious source terms related to the difficulties of satisfying numerically the metric identities and in order to guarantee the satisfaction of the freestream preservation condition we propose an original procedure.

We define the water depth as h and the depth averaged velocity vector as \vec{u} , whose components are defined in the Cartesian system of reference. Let be $\vec{v} = \vec{u}h$. In order to introduce the notation to be used, we consider a transformation $x^l = x^l(\xi^1, \xi^2)$ from the Cartesian coordinates \vec{x} to the curvilinear coordinates $\vec{\xi}$ (note that superscripts indicate components and not powers in the present notation). Let $\vec{g}_{(l)} = \partial\vec{x}/\partial\xi^l$ be the covariant base vectors and $\vec{g}^{(l)} = \text{grad}(\xi^l)$ the contravariant base vectors. Let r^l be the contravariant components in the curvilinear coordinate system of the vector \vec{v} . The integral form of the depth-integrated continuity equation is:

$$\int_{\Delta A} \frac{\partial h}{\partial t} dA + \int_L r^m n_m dL = 0, \quad (1)$$

where ΔA is an arbitrary surface element whose contour line is L , and n_m is the covariant outward normal. The integral form of the depth-integrated momentum equation is:

$$\begin{aligned} \int_{\Delta A} \vec{g}^{(l)} \cdot \vec{g}_{(k)} \frac{\partial r^k}{\partial t} dA + \int_L \vec{g}^{(l)} \cdot \vec{g}_{(k)} \left(\frac{r^k r^m}{h} + g^{mk} \frac{h^2}{2} \right) n_m dL = \\ \int_{\Delta A} \vec{g}^{(l)} \cdot \vec{g}_{(k)} \left(Ghg^{mk} \frac{\partial H}{\partial \xi^m} + R^k \right) dA, \end{aligned} \quad (2)$$

where $R^k = G(r^k |\vec{r}|)/(\chi^2 h^2)$ is the bed resistance term, $\chi = (1/M)h^{1/6}$ is the friction coefficient, M is the Manning friction factor, G is the constant of gravity, H is the bed height and $\vec{g}^{(l)}$ indicates the l^{th} contravariant base vector defined at the center of the surface element. Equations (1) and (2) represent the integral expressions of the shallow water equations in contravariant formulation, in which Christoffel symbols are not present.

The numerical integration of Equations (1) and (2) is performed by an Upwind WENO scheme. The Upwind WENO scheme needs a flux calculation at the cell interfaces. These fluxes are calculated by means of the solution of a Riemann problem. An Exact Riemann Solver is used in this framework. All necessary Riemann problems are solved in a locally valid orthonormal basis. This orthonormalization allows one to solve Cartesian Riemann problems that are devoid of geometric terms. The model is validated against several benchmark tests, and the results are compared with theoretical and alternative numerical solutions. The results of these tests show that: the proposed scheme is fifth-order accurate in space and fourth-order accurate in time; the exact C-property for quiescent flow over non-flat bottom profiles is achieved; the original procedure proposed in order to correct the effects produced by the spurious source terms related to the difficulties of satisfying numerically the metric identities, allows to satisfy the freestream preservation property even in highly distorted meshes.

Mathematics Subject Classification 2000: 76D99, 76M12

¹Department of Civil, Architectural and Environmental Engineering
University of Rome "La Sapienza"
Faculty of Engineering. Via Eudossiana 18, Rome, Italy
francesco.gallerano@uniroma1.it

C U R S O S E C O N G R E S O S
Nº 202

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.

