

# SHORT COURSE ON ADVANCED NUMERICAL METHODS FOR HYPERBOLIC EQUATIONS

## Lecturers

Prof. Dr.-Ing. Michael Dumbser and Dr. Elena Gaburro  
Department of Civil and Environmental Engineering  
Laboratory of Applied Mathematics  
University of Trento, Italy

## Dates

From Monday 10<sup>th</sup> February to Friday 14<sup>th</sup> February 2020

## Venue

University of Trento, Via Mesiano, 77, I-38123 Trento, ITALY

## SUMMARY

The short course on advanced numerical methods consists of a structured intensive one-week programme of 36 hours of theoretical lectures and computer laboratory exercises on advanced numerical methods for hyperbolic partial differential equations with applications in engineering and science. The course covers finite volume methods, the exact and approximate solution of the Riemann problem, second order TVD methods, higher order ENO, WENO and discontinuous Galerkin methods, as well as the discretization of non-conservative problems. Special emphasis is put also on numerical methods that are able to handle complex geometries. In particular, unstructured Finite Volume and discontinuous Galerkin schemes as well as mesh-free particle methods are presented. The course is primarily designed for PhD students and post-doctoral researchers in applied mathematics, engineering, physics, computer science and other scientific disciplines. The course may also be of interest to senior researchers in industry and research laboratories, as well as to senior academics. The lectures on the theory will be supplemented with laboratory-based computer exercises to provide hands-on experience to all participants on the practical aspects of numerical methods for hyperbolic problems and applications using MATLAB programs specially designed for the course.



## CONTENTS

Review of basic theoretical aspects of hyperbolic conservation laws and numerical concepts for hyperbolic equations. Finite volume methods for one-dimensional systems. Godunov's method. The Riemann problem. Approximate Riemann solvers. Godunov-type finite volume methods for non-linear systems. Construction of higher order non-oscillatory methods via non-linear schemes: TVD, ENO and WENO reconstruction procedures. Discontinuous Galerkin Finite Element methods for one-dimensional problems. The well-balanced property and numerical methods for non-conservative hyperbolic systems. Extension to multiple space dimensions on Cartesian grids.

Complex geometries using unstructured triangular meshes in two space dimensions and using mesh-free approaches.

**Mesh-based algorithms:** Finite volume schemes on unstructured meshes for two-dimensional geometries. Second-order reconstruction and slope limiting on unstructured meshes. Applications to the shallow water equations and the Euler equations of compressible gas dynamics. High order discontinuous Galerkin finite element methods on unstructured meshes.

**Mesh-free algorithms:** Introduction to Lagrangian particle methods. Guidelines for implementation of smooth particle hydrodynamics (SPH) based on approximate Riemann solvers.

On the last day, the course is rounded-off by advanced seminar-style lectures with outlooks to the following topics: better than second order schemes on unstructured meshes, high order methods on space-time adaptive grids (AMR), time-accurate local time stepping (LTS), high order Lagrangian schemes on moving unstructured meshes, applications to compressible multi-phase flows, nonlinear elasto-plasticity, numerical general relativity and the Einstein-Euler system.

## ABOUT TRENTO AND THE DOLOMITES

The historical city of Trento is situated in the autonomous Italian region of Trentino - Südtirol, close to the world-famous mountains called *Dolomites*. Trento is very easy to reach by car or train from Austria (150 km south of Innsbruck) and from Verona (90 km north of Verona). The nearest and most convenient airport is Verona Airport, 15 minutes from the Verona train station. The region around Trento is of extraordinary beauty, with its unique mountains and lakes that offer the participants many exciting outdoor activities like skiing, hiking or climbing.



## COST

Students and post-docs: **€ 500**; Senior academics and others: **€ 1000**; (free of "VAT tax" as art. 10 DPR 633/72). The fees cover lectures, laboratory exercises, lecturing material and demonstration programs in MATLAB. Furthermore, the course fee includes the coffee breaks and one social event (dinner).

## REGISTRATION AND ADMINISTRATIVE INFORMATION

Participants must register via e-mail, sending the attached registration form to [michael.dumbser@unitn.it](mailto:michael.dumbser@unitn.it).

For further information on registration and payment, please e-mail to:

Prof. Dr.-Ing. Michael Dumbser ([michael.dumbser@unitn.it](mailto:michael.dumbser@unitn.it))

Tel. +39 0461 28 2659 Fax. +39 0461 28 2672

Once registered for the course you can proceed and make the necessary arrangements for attending the course, such as travel arrangements, booking the hotel, etc. Once the payment has been made please send a copy of the receipt via e-mail to the address indicated above.

**Payment** of the **course fee** must be made **only after registration** and **after January 1<sup>st</sup> 2020**, but **before 1<sup>st</sup> February 2020** by **bank transfer** to:

BANCA POPOLARE DI SONDRIO

Piazza Centa - Trento (Italy)

Account holder's name: Università degli Studi di Trento

Account holder's VAT number: 00340520220

IBAN: IT06 N 05696 01800 000003108X60

SWIFT/BIC Code: POSOIT22

Bank transfers must be net of all bank charges and must specify the **name of the participant** and the subject "**NUMHYP course**".



## REGISTRATION FORM

### Short Course on "Advanced Numerical Methods for Hyperbolic Equations"

Trento, 10 February - 14 February 2020

PARTICIPANT DATA	
FIRST NAME *	
LAST NAME *	
PLACE AND DATE OF BIRTH *	
PROFESSION *	
ADDRESS *	
CITY *	
COUNTRY *	
PERSONAL FISCAL CODE (for Italian residents only)	
TEL *	
E-MAIL *	
SIGNATURE *	
INVOICE DETAILS	
<b>Only needed for invoices issued to the name of an institution or a private company</b>	
NAME	
ADDRESS	
CITY	
COUNTRY	
<b>VAT NUMBER **</b>	

\* compulsory information

\*\* The **VAT number** is **compulsory** if you want the invoice to be issued to an institution like a **University** or a **governmental research laboratory** or a **private company**. If the invoice is issued to the name of the participant as a natural person (default option), no VAT number is needed.

**Confidentiality.** The information that you have given on this form will be computer processed in compliance with the Italian law 675/96 on data protection. It may be utilized to keep you informed on activities by University of Trento in the future. Your information will not be communicated to third parties. You may ask at any time for its cancellation by written application to the administrative officer of the Course Secretariat.

Do you give permission for the information provided above to be available to selected businesses?

Yes  No

Please send the registration form to the attention of **Prof. Dr.-Ing. Michael Dumbser**, Department of Civil, Environmental and Mechanical Engineering, University of Trento, Via Mesiano 77, I-38123 Trento – ITALY. e-mail: [michael.dumbser@unitn.it](mailto:michael.dumbser@unitn.it)