University Academic Curriculum Vitae

Personal information Name: MAURIZIO TAVELLI

Updated: **01/05/2022**

Education since leaving school

Degree in Mathematics
Department of Mathematics, University of Trento
From 2006 to 2010

Title of the thesis: “Sul filtraggio e controllo stocastico”,
written under the supervision of Prof. Luciano Tubaro.

Master degree in Mathematics
Department of Mathematics, University of Trento
From 2010 to 2012

Title of the thesis: “High resolution methods for scalar transport problems in compliant systems of arteries”,
written under the supervision of Prof. Vincenzo Casulli.

PhD in Mathematics
Department of Mathematics, University of Trento
From 2012 to 2015

Development of new numerical schemes with focus on Computational Fluid Dynamics. In particular I developed some new arbitrary high order semi-implicit numerical schemes for shallow water and incompressible Navier-Stokes equations on unstructured staggered meshes.

Title of the thesis: “Arbitrary high order discontinuous Galerkin methods for the shallow water and incompressible Navier-Stokes equations on unstructured staggered meshes”,
written under the supervision of Prof. Michael Dumbser and Prof. Vincenzo Casulli.

Present appointment

Research Collaborator
01/01/2022 – 30/04/2022
Department of Civil, Environmental and Mechanical Engineering, University of Trento , Italy
I am working on the topic of semi-implicit schemes for fluid and solid mechanics in the unified framework of the Godunov-Peshkov and Romenski model**.**

Post-doc
15/09/2020 – 30/10/2021
Free University of Bolzano, Piazza università 1, I-39100 Bolzano, Italy

I worked on the topic of semi-implicit algorithms for environmental flows with fine sediment, bubbles interaction and density currents in the case of complex free surface flows.

Post-doc
15/09/2019 – 14/09/2020
Free University of Bolzano, Piazza università 1, I-39100 Bolzano, Italy

I worked on the topic of semi-implicit algorithm for environmental flows with fine sediment transport.

Post-doc
01/11/2015 – 14/09/2019
Department of Civil, Environmental and Mechanical Engineering, University of Trento

In the first part I focused on the extension of this new class of arbitrary high order numerical schemes on unstructured staggered meshes, developed during the PhD, to the compressible Navier-Stokes equations at all Mach numbers.
Then from 01/01/2017 I moved to the international project **ExaHyPE** in which I deal with high order numerical methods for geophysics on adaptive Cartesian meshes.

Awards

Winner of the best PhD thesis in Mathematics at the University of Trento, academic year 2016-2017.

Finalist of the European ECMI Anile prize 2018 competition.

Winner of the INDAM contribution "Finanziamento Giovani Ricercatori 2019-2020", total contribution amount 1200€.

Other titles

I got the Abilitazione Scientifica Nazionale (ASN) in the following sectors:

- 01/A5 Analisi Numerica – Seconda fascia, valid from 09/11/2020 to 09/11/2029
- 09/A1 Ingegneria Aeronautica, Aerospaziale e Navale – Seconda fascia, valid from 10/11/2020 to 10/11/2029

Participation in exhibitions (where applicable)

I attended the following conferences as speaker:

- 10th International UnTRIM Users Workshop,
  Trento 27-29 May 2013
  Title: "A high order semi-implicit discontinuous Galerkin method for the two dimensional Shallow Water Equations on unstructured staggered non-orthogonal grids"
- Modelling of Physiological Flows,
  Sardegna 11-14 June 2013
  Title: "High resolution methods for advection-diffusion problems in compliant arterial systems"
- 11th International UnTRIM Users Workshop,
  Trento 19-21 May 2014

Title: “A staggered semi-implicit discontinuous Galerkin method for the two dimensional shallow water and incompressible Navier-Stokes equations”

- XX International Conference on Computational Methods in Water Resources,
  Stoccarda 10-13 June 2014
  Title: "A high order semi-implicit discontinuous Galerkin method for the two dimensional shallow water equations on staggered unstructured meshes"

- International Conference on Spectral and High Order Methods,
  Salt Lake City (Utah) 23-27 June 2014
  Title: “A staggered semi-implicit discontinuous Galerkin method for the two dimensional incompressible Navier-Stokes equations”

- European Workshop on High Order Nonlinear Numerical Methods for Evolutionary PDEs: Theory and Applications,
  Trento 16-20 March 2015
  Title: “A staggered semi-implicit arbitrary high order discontinuous Galerkin method for the two dimensional incompressible Navier-Stokes equations”

- High order reconstruction and well balancing techniques for hyperbolic conservation and balance laws,
  Torino 15-16 April 2015
  Title: “A staggered semi-implicit arbitrary high order discontinuous Galerkin method for the incompressible Navier-Stokes equations”

- 12th International UnTRIM UsersWorkshop,
  Trento 18-20 May 2015
  Title: “A staggered arbitrary high order discontinuous Galerkin method for the two and three-dimensional incompressible Navier-Stokes equations”

- Numerical approximations of hyperbolic systems with source terms and applications,
  Cortona 14-20 June 2015
  Title: “A staggered semi-implicit arbitrary high order discontinuous Galerkin method for the incompressible Navier-Stokes equations”

- 13th International UnTRIM UsersWorkshop,
  Trento 30 May- 1 June 2016
  Title: “A staggered space-time discontinuous Galerkin method for the three-dimensional incompressible Navier-Stokes equations on unstructured tetrahedral meshes”

- ECCOMAS Congress 2016,
  Creta 5-10 June 2016
  Title: “A staggered arbitrary High Order semi-implicit discontinuous Galerkin method for the incompressible Navier-Stokes equations”

- 19th European Conference on Mathematics for Industry,
  Santiago de Compostela 13-17 June 2016
  Title: "A staggered space-time discontinuous Galerkin method for the three-dimensional incompressible Navier-Stokes equations on unstructured tetrahedral meshes"

- Honom 2017,
  Stoccarda, 27-31 March 2017
  Title: "A multi-dimensional, all Mach-number, arbitrary high order space-time discontinuous Galerkin method for the compressible Navier-Stokes equations on staggered unstructured meshes"

- 19th International Conference on Finite Elements in Flow Problems,
  Roma, 5-7 April 2017
  Title: "A multi-dimensional, all Mach-number, arbitrary high order space-time discontinuous Galerkin method for the compressible Navier-Stokes equations on staggered unstructured meshes"

- 14th International UnTRIM Users Workshop,
  Trento 15-17 May 2017
  Title: “A pressure-based semi-implicit space-time discontinuous Galerkin method for the compressible Navier-Stokes equations”

- EQUADIFF 2017,
  Bratislava, 24-28 July 2017
  Title: “An arbitrary high order space-time DG method for the compressible Navier-Stokes equations on unstructured meshes”

- 4th Congreso de jòvenes investigadores,
  Valencia, 4-8 September 2017
  Title: "A semi-implicit discontinuous Galerkin method on staggered unstructured meshes for the solution of the compressible Navier–Stokes equations at all Mach numbers"

- Shark-FV 2018 conference,
  Minho, Portugal, 21-25 May 2018
  Title: “High order numerical schemes for linear elasticity”

- 15th International UnTRIM Users Workshop,
  Trento 28-30 May 2018,
  Title: “Arbitrary high order DG Galerkin finite element schemes on staggered unstructured meshes for linear elasticity"

- SIMAI 2018,
  Roma, 2-6 July 2018
  Title: “High order numerical schemes for linear elasticity”

- HONOM conference 2019,
  Madrid 1-5 April 2019,
  Title: “High order numerical schemes for linear and non-linear elasticity”

- ICIAM 2019,
  Valencia, 15-19 July 2019
  Title talk 1: "A high order parallel Eulerian-Lagrangian algorithm for advection-diffusion problems on unstructured meshes"
  Title talk 2: "High order numerical schemes for linear elasticity and dynamic rupture propagation"

- 17th International UnTRIM Users Workshop,
  Trento 11-13 May 2021,
  Title: “On the construction of conservative semi-Lagrangian IMEX schemes for hyperbolic balance laws”

I organized the online-workshop titled "1st Workshop on the use of Numerical Analysis in Engineering", Bolzano, 1 Mar 2021, see https://www.unibz.it/it/events/137343-1st-workshop-on-the-use-of-numerical-analysis-in-engineering
Title of the talk: "High order schemes for fluid and solid mechanics with rupture"

Experience in academic teaching

Teaching support
Department of Mathematics, University of Trento
II semester aa. 2017-2018
II semester aa. 2016-2017
II semester aa. 2015-2016
II semester aa. 2014-2015

I carried out teaching support for the course "*Scientific Computing*" aimed at master students in Mathematics.

Teaching activity: Introduction to Fortran for scientific computing, development of some finite difference and finite elements codes and a final application to the incompressible Navier-Stokes, shallow water and Navier-Stokes equations with natural convection. My contribution consisted in 15 hours of lectures and exercises.

Teaching support
Department of Civil, Environmental and Mechanical Engineering, University of Trento
I semester aa. 2018-2019
I semester aa. 2017-2018
I semester aa. 2016-2017
I semester aa. 2015-2016
I semester aa. 2014-2015
I semester aa. 2013-2014

I carried out teaching support for the course "*Calcolo Numerico*" aimed at students in civil engineering.

Teaching activity: Basic topics in numerical analysis about solution of linear and non-linear systems, numerical interpolation, numerical approximation of ODEs, initial and boundary value problems. In particular, I focused on the practical implementation of the above arguments. My contribution consisted in 30 hours of tutoring and exercises.

Memberships

- Participant of the European Horizon 2020 project "*An Exascale Hyperbolic PDE Engine*", ExaHyPE, Grant agreement No.671698

- Participant to the ERC starting Grant project "*Space-Time Methods for Multi-Fluid Problems on Unstructured Meshes*", STiMulUs, ERC Grant agreement No. 278267

- Reviewer of the following peer-reviewed international journals:
  Applied Mathematics and Computation;
  International Journal for Numerical Methods in Fluids;
  Engineering Computations;
  Computer and Fluids;
  Journal or Scientific Computing;
  Advances in Mechanical Engineering;
  MDPI, Mathematics; Symmetry; Computation;
  ISH Journal of Hydraulic Engineering;
  Numerical Methods for Partial Differential Equations

- Member of the following projects for which we gained access to the SuperMUC supercomputer in Munich, the HazelHen system in Stuttgart and the Marconi supercomputer in Italy:

  - 2018-2019, ExaHyPE project, 19th call for GCS large-scale projects, SuperMUC, Granted 18 million core-h;

  - 2017-2018, HOMCoG project, ISCRA class C project, Granted 0.4 million core-h;

  - 2016-2017, HOSTELDG project, call for Tier1 HPC Access at HLRS, Granted 9 million core-h;

  - 2014-2015, STiMulUS project, 10th call nr.2014112638, SuperMUC, Granted 8 million core-h;

  - 2013-2014, STiMulUS project, 8th call nr. 2013091889, SuperMUC, Granted 8 million core-h;

  - STiMulUS project, 6th call nr. 2012071312, SuperMUC, Granted 3 million core-h.

Publications

1 Tavelli, W. Boscheri, G. Stradiotti, G.R. Pisaturo, M. Righetti. "A mass-conservative semi-implicit volume of fluid method for the Navier-Stokes equations with high order semi-Lagrangian advection scheme", *Computer and Fluids*, 240, 105443, 2022
DOI: 10.1016/j.compfluid.2022.105443

2 W. Boscheri, M. Tavelli and L. Pareschi. "On the construction of conservative semi-Lagrangian IMEX advection schemes for multiscale time dependent PDEs", *Journal of Scientific Computing*, 90, 97, 2022
DOI: 10.1007/s10915-022-01768-0

3 W. Boscheri, G. Dimarco and **M. Tavelli**,
"An efficient second order all Mach finite volume solver for the compressible Navier–Stokes equations",*Computer Methods in Applied Mechanics and Engineering*, 2021, 374, 113602
DOI: 10.1016/j.cma.2020.113602

4 A. A. Gabriel, D. Li, S. Chiocchetti, **M.Tavelli**, I. Peshkov, E. Romenski, M. Dumbser.
"A unified first order hyperbolic model for nonlinear dynamic rupture processes in diffuse fracture zones"
Philosophical Transactions of the Royal Society A,2021, 379(2196), 20200130
DOI: 10.1098/rsta.2020.0130
PREPRINT: https://arxiv.org/abs/2007.01026

5 **M. Tavelli**, S. Chiocchetti, E. Romenski, A.A. Gabriel and M. Dumbser.
"Space-time adaptive ADER discontinuous Galerkin shcmes for nonlinear hyperelasticity with material failure",
Journal of Computational Physics, 2020, 422,109758
DOI: 10.1016/j.jcp.2020.109758

6 F. L. Romeo, M. Dumbser, **M. Tavelli**.
"A novel staggered semi-implicit space-time discontinuous Galerkin method for the incompressible Navier-Stokes equations",
Communications on Applied Mathematics and Computations, 2020
DOI :10.1007/s42967-020-00077-3

7 W. Boscheri, G. Dimarco, R. Loubère, **M. Tavelli**, M.H. Vignal.
"A second order all Mach number IMEX finite volume solver for the three dimensional Euler equations",
Journal of Computational Physics , 415, 2020,
DOI:10.1016/j.jcp.2020.109486

8 **M. Tavelli**, S. Piccolroaz, G. Stradiotti, G. R. Pisaturo, M. Righetti.
"A New Mass-Conservative, Two-Dimensional, Semi-Implicit Numerical Scheme for the Solution of the Navier-Stokes Equations in Gravel Bed Rivers with Erodible Fine Sediments",
Water , 12(3), 690, 2020, DOI: 10.3390/w12030690

9 S. Busto, **M. Tavelli**, W. Boscheri, M. Dumbser.
"Efficient high order accurate staggered semi-implicit discontinuous Galerkin methods for natural convection problems",
Computers and Fluids , 2020,
DOI: 10.1016/j.compfluid.2019.104399

10 A. Reinarz, D. E. Charrier, M. Bader, L. Bovard, M. Dumbser, K. Duru, F. Fambri, A.A. Gabirel, J.M. Gallard, S. Koppel, L. Krenz, L. Rannabauer, L. Rezzolla, P. Samfass, **M. Tavelli**, T. Weinzierl.
"ExaHyPE: An engine for parallel dynamically adaptive simulations of wave problems",
Computer Physics Communications , 2020,
DOI: 10.1016/j.cpc.2020.107251

11 ***M. Tavelli***, W. Boscheri.
"A high-order parallel Eulerian-Lagrangian algorithm for advection-diffusion problems on unstructured meshes",
Numerical Methods in Fluids , 388, pp 1-16, 2019,
DOI: 10.1002/fld.4756

12 ***M. Tavelli***, M. Dumbser, D.E. Charrier, L. Rannabauer, T. Weinzierl and M. Bader.
"A simple diffuse interface approach on adaptive Cartesian grids for the linear elastic wave equations with complex topography",
Journal of Computational Physics, 388, pp 158-189, 2019,
DOI: 10.1016/j.jcp.2019.02.004

13 *M. Dumbser*, D.S. Balsara, **M. Tavelli**, F. Fambri.
"A divergence-free semi-implicit finite volume scheme for ideal, viscous, and resistive magnetohydrodynamics",
International Journal for Numerical Methods in Fluids, 2018, DOI: 10.1002/fld.4681.

14 *M. Dumbser*, F. Fambri, **M. Tavelli**, M. Bader and T. Weinzierl.
"Efficient implementation of ADER discontinuous Galerkin schemes for a scalable hyperbolic PDE engine",
Advanced Numerical Methods in Applied Sciences, 63, 2018, DOI: 10.3390/axioms7030063.

15 ***M. Tavelli*** and M. Dumbser.
"Arbitrary high order space-time DG schemes for linear elasticity

on staggered unstructured meshes",
Journal of Computational Physics, 366, 2018, pp 386-414, DOI: 10.1016/j.jcp.2018.03.038.

16 *M. Dumbser*, F. Fambri, I. Furci, M. Mazza S. Serra-Capizzano, **M. Tavelli.**
"Staggered discontinuous Galerkin methods for the incompressible Navier–Stokes equations: Spectral analysis and computational results",
Numerical Linear Algebra with Applications, 25, 2018, DOI: 10.1002/nla.2151.

17 ***M. Tavelli*** and M. Dumbser.
"A pressure-based semi-implicit space–time discontinuous Galerkin method on staggered unstructured meshes for the solution of the compressible Navier–Stokes equations at all Mach numbers",
Journal of Computational Physics, 341, 2017, pp 341-376, DOI: 10.1016/j.jcp.2017.03.030.

18 ***M. Tavelli*** and M. Dumbser.
"A staggered space-time discontinuous Galerkin method for the three-dimensional incompressible Navier-Stokes equations on unstructured tetrahedral meshes",
Journal of Computational Physics, 319, 2016, pp 294-323, DOI: 10.1016/j.jcp.2016.05.009.

19 ***M. Tavelli*** and M. Dumbser.
"A staggered space-time discontinuous Galerkin method for the incompressible Navier-Stokes equations on two-dimensional triangular meshes",
Computers and Fluids, 119, 2015, pp 235-249, DOI: 10.1016/j.compfluid.2015.07.003.

20 ***M. Tavelli*** and M. Dumbser.
"A staggered semi-implicit discontinuous Galerkin method for the two dimensional incompressible Navier–Stokes equations",
Applied Mathematics and Computation, 248, 2014, pp 70-92, DOI: 10.1016/j.amc.2014.09.089.

21 ***M. Tavelli*** and M. Dumbser.
"A high order semi-implicit discontinuous Galerkin method for the two dimensional shallow water equations on staggered unstructured meshes",
Applied Mathematics and Computation, 234,2014,pp 623-644, DOI: 10.1016/j.amc.2014.02.032.

22 ***M. Tavelli***, M. Dumbser and V. Casulli.
"High resolution methods for scalar transport problems in compliant systems of arteries", *Applied Numerical Mathematics*, 74, 2013, pp 62-82, DOI: 10.1016/j.apnum.2013.06.009.

Recently submitted works:

W. Boscheri, M. Tavelli, "High order semi-implicit schemes for viscous compressible flows in 3D", *Applied Mathematics and Computation*, submitted.

W. Boscheri, M. Tavelli, N. Paoluzzi, “High order Finite Difference/Discontinuous Galerkin schemes for the incompressible Navier-Stokes equations with implicit viscosity”, *Communications in Applied and Industrial Mathematics*, submitted

Up to now I have a total of **406** citations and an h-index of **12** (source Scopus).

Statement of interest

My background covers a wide range of numerical schemes applied to fluid dynamics and geophysical flows. The schemes I designed are arbitrary high order in space and time and were applied to two and three-dimensional problems.
We discovered that the combination of semi-implicit and high order DG polynomials allows both to maintain the good mathematical properties of semi-implicit schemes and to achieve arbitrary high order in space and time. This kind of approach usually requires coarsest meshes to obtain an accurate solution, with a save in terms of computational effort.
We also derived some high order semi-Lagrangian schemes that can run in the DG framework and distributed memory systems, see [11] and [9].

In the framework of geophysical applications we used a modified version of Godunov-Peshkov and Romenski model that is able to describe the continuum mechanics from elastic, elastoplastic and fluid mechanics. This general model was applied to elastoplastic material with dynamic rupture, see [5] and [4]. In [4] we place a proof of concept that this method can also be used for phase transitions as needed for melting processes.
The codes developed so far are fully parallelized and were tested on massive supercomputers like SuperMUC in Munich and the Cray XC40 (Hazel Hen) system in Stuttgart.

In conclusion I have experience in the design and implementation, by scratch, of general 2D/3D arbitrary high order methods on unstructured and structured meshes with a particular application to fluid dynamics. I got also a good experience in the efficient parallel implementation of the codes, that is a crucial point for large scale simulations.

Language competence

Italian: first language.
English: good level of written and spoken language

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