FIRAS DHAOUADI

PhD in mathematics, Applied mathematics engineer

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CURRENT POSITION

19/12/2022 - current, Università degli Studi di Trento - Laboratory of Applied Mathematics
Assistant professor within Prof. Michael Dumbser's team working on hyperbolic reformulations of nonlinear dissipative and dispersive equations and related structure-preserving numerical methods.

RESEARCH TOPICS

- Variational principles, causal models in mechanics, hyperbolic PDEs and conservation laws.
- Hyperbolic reformulations of nonlinear dissipative and dispersive equations.
- Development of structure-preserving numerical methods for hyperbolic PDEs with involutions.
- Scientific computing, finite volumes, Godunov-type schemes, IMEX schemes.
- Multiphase flows, Euler-Korteweg equations, Cahn-Hilliard equation, flows with surface tension.

EDUCATION

- **01/10/2017 - 31/12/2020, Université Paul Sabatier - Institut de Mathématiques de Toulouse**
  PhD in mathematics: An augmented Lagrangian approach for Euler-Korteweg type equations.
- **01/09/2016 - 30/09/2017, Aix-Marseille Université - Polytech' Marseille**
  Master II: Multiphase flows, energetics and combustion. Final mark 18.16/20, rank 1/9.
- **01/09/2013 - 31/08/2016, Ecole Nationale d'Ingénieurs de Tunis**
  National engineering diploma in modeling for industry and services.
- **05/09/2011 - 01/07/2013, Institut Préparatoire aux Etudes d'Ingénieurs d'El Manar**
  Pre-engineering school with a major in mathematics and physics, rank 1/287.

RESEARCH EXPERIENCE

- **Assistant professor: 19/12/2022 - present, DICAM, Trento**
  - Development and implementation of strucutre-preserving schemes for the hyperbolic Navier-Stokes-Korteweg equations.
  - Development of a new hyperbolic, thermodynamically compatible model for heat conduction.
  - Implementation of a structure-preserving scheme for a hyperbolic two-phase flow.
  - Development of a hyperbolic model for the Cahn-Hilliard equation.
- **Postdoctoral fellowship: 15/03/2021 - 18/12/2022, DICAM, Trento**
  - Development of a new hyperbolic model for the Navier-Stokes-Korteweg equations.

- Theoretical and numerical study of the model using high-order ADER-DG methods.
- Analysis of GLM curl-cleaning methods and assesment of curl errors of the numerical method.

- **PhD in Mathematics: 01/10/2017 - 31/12/2020, IMT, Toulouse**
  - Development of a causal first-order hyperbolic version of Euler-Korteweg equations from least-action principles, using augmented Lagrangian methods.
  - Application of the method to the nonlinear Schrödinger equation and to thin film flows.
  - Numerical implementation of second order accurate IMEX finite volume schemes using fortran.
  - Rigorous development from variational principles of stationary solutions for stationary droplets.
- **Project TOLOSA CEMRACS 2019 : 15/07/2019 - 23/08/2019, CIRM, Marseille**
  - Rigorous justification of the use of modified equations to obtain stability conditions for a class of linear numerical schemes.
  - Implementation of a Mathematica code to derive necessary and sufficient stability conditions for linear numerical schemes.
- **Master internship : 01/03/2017 - 31/08/2017, IUSTI, Marseille**
  - Development of a first-order hyperbolic model approximating the defocusing nonlinear Schrödinger equation using an augmented Lagrangian approach.
  - Numerical implementation of MUSCL-Hancock finite volume schemes using fortran.
- **Research internship : 01/02/2016 - 31/08/2016, IUSTI, Marseille**
  - Analysis of the effects of gravity on the heat transfer at the onset of nucleate boiling.
  - Numerical study of the thermal boundary layer in the vicinity of a tiltable heating wall in different orientations.
- **Research internship : 01/07/2015 -05/09/2015, I2E-EPPM, Tunis**
  - Theoretical and numerical study of the coalescence of two drops assuming rigid mobile interfaces.
  - Implementation of a Lax-Wendroff scheme on Matlab.

TEACHING EXPERIENCE

Total amount of teaching hours: **249.5h** distributed as follows:

- **2022-2023 - University of Trento,**
  - *Course on numerical methods for turbulent flows*, graduate level, 5h of lectures + 5 hours of computer exercises.
- **2022-2023 - University of Trento, Turbulence course**
  - *Course on numerical methods for turbulent flows*, graduate level, 5h of lectures + 5 hours of computer exercises.
- **2021-2022 - University of Trento,**
  - Organizer of the Unitn HPC Summer school 2022.
  - *Intensive course on High performance computing*: graduate level, 16h of lectures + 8 hours of computer exercises.

- *Intensive course on Advanced numerical methods for hyperbolic equations*, graduate level, 2h lectures + 18h computer exercises.

- **2021-2022 - University of Trento, Winter school 2022**
  - *Intensive course on Advanced numerical methods for hyperbolic equations*, graduate level, 2h lectures + 18h computer exercises.
- **2019-2020 - INSA-Toulouse**
  - *Numerical analysis*, undergraduate level, 4h lectures + 58h computer sessions.
- **2018-2019 - INSA-Toulouse**
  - *Numerical analysis*, undergraduate level, 32.5h computer sessions.
  - Main coordinator of the course: *Numerical resolution of differential equations*, undergraduate level, 15h exercises+ 15h computer sessions+ 6h lectures.
- **2017-2018 - INSA-Toulouse**
  - *Mathematics*, undergraduate level : 50h exercises.
  - *Numerical resolution of differential equations*, undergraduate level, 15h computer sessions.
- **Taught notions:**
  - **Numerical analysis:** Machine error, numerical integration, interpolation, root-finding algorithms (Newton's method, bisection method), numerical methods for linear systems, least squares method, eigenvalue algorithms (power iteration), finite differences for first and second order differential equations, High-order Finite volume and Discontinuous Galerkin methods for hyperbolic equations in 1D and 2D, on structured and unstructured grids, WENO limiters, ADER schemes, SIMPLE method for the the incompressible Navier-Stokes, Semi-implicit methods for the $k-\varepsilon$ model.
  - **High-performance computing:** Introduction to HPC, Complexity analysis, Shared memory vs Distributed memory systems, MPI communcation functions, Parallelizing sums, Parallelizing a finite volumes code, PBS scripting, HPC cluster usage.
  - **Mathematics:** First order linear differential equations, Taylor expansions, asymptotic analysis, integrals, improper integrals, systems of linear equations, linear Algebra, eigenvalues, eigenvectors.
  - **Other:** Python basics for scientific applications.

AWARDS AND FUNDRAISING

- 2022: Won the NextGenerationEU, Azione 247 MUR Young Researchers – SoE line, grant for three years of assistant professorship. value: **150000€**.
- 2021: Won the UniTn starting grant for writing competitive international proposals. value **12000€**.
- 2017: Won the french *national ministry of education and research* scholarship for doctoral studies. value: **68973.45€**.
- 2016: Won a scholarship (Med-Accueil exchange program for Mediterranean students) to fund Master studies in Aix-Marseille Université. value: **5400€**.
- 2013: Excellence prize awarded for the *best student of the institute* (rank 1/287 in Institut Préparatoire aux Etudes d'Ingénieurs d'El Manar, Tunisia).

CONFERENCES AND SEMINARS ORGANIZATION

- Conference chair and main organizer of the international conference PROHYP2024: *3rd International workshop on Perspectives on Multiphase Fluid Dynamics, Continuum Mechanics and Hyperbolic Balance Laws (📍 Trento, Italy, 50 participants)*
- Member of the organizing committee (local chair) for the international conference NUMHYP2021: *7th international conference on Numerical methods for Hyperbolic problems (📍 Trento, Italy, 110 participants)*
- Founder of the annual seminar *Modeling and simulation day* at the Ecole Nationale d'Ingénieurs de Tunis. Co-organizer of the 2014 and 2015 editions.

SCIENTIFIC COMMUNICATIONS

- **HONOM 2024 - 📍 Crete, Greece (International conference):**
  A hyperbolic approximation of the Cahn-Hilliard equation. (Talk)
- **Sixth Workshop on Compressible Multiphase Flows 2024 - 📍 Strasbourg, France (Workshop):**
  A hyperbolic approximation of the Cahn-Hilliard equation. (Talk)
- **IMB Seminar 2024 - 📍 Bordeaux, France (Invited Seminar):**
  Hyperbolic models for diffusion equations. (Talk)
- **PROHYP 2023 - 📍 Trento, Italy (Workshop):**
  An Eulerian hyperbolic model for heat transfer derived via Hamilton's principle. (Talk)
- **DROPIT Seminar 2024 - 📍 Stuttgart, Germany (Seminar):**
  A structure-preserving scheme for a hyperbolic approximation to the NSK equations. (Talk)
- **WONAPDE 2024 - 📍 Concepcion, Chile (International conference):**
  Hyperbolic approximation and numerical methods for the Navier-Stokes-Korteweg equations. (Talk)
- **Hirschegg Workshop 2023 - 📍 Hirschegg, Austria (Workshop):**
  A structure-preserving scheme for a hyperbolic approximation to the NSK equations. (Talk)
- **NUMHYP 2023 - 📍 Bordeaux, France (International conference):**
  A hyperbolic model for heat transfer in compressible flows. (Poster)
- **GdT Hyperbo 2023 - 📍 Marseille, France (Workshop):**
  A first-order hyperbolic reformulation of the Navier-Stokes-Korteweg equations. (Talk)
- **MULTIMAT 2022 - 📍 Zurich, Switzerland (International conference):**
  A Hyperbolic reformulation of the Navier-Stokes-Korteweg equations. (Talk)
- **CEDYA 2022 - 📍 Zaragoza, Spain (International conference):**
  A Hyperbolic reformulation of the Navier-Stokes-Korteweg equations. (Talk)
- **HYP 2022 - 📍 Malaga, Spain (International conference):**
  A Hyperbolic reformulation of the Navier-Stokes-Korteweg equations. (Talk)
- **PROHYP 2022 - 📍 Marseille, France (Workshop):**
  A Hyperbolic reformulation of the Navier-Stokes-Korteweg equations. (Talk)
- **Trento Winter School 2022 - 📍 Trento, Italy (Winter school):**

Hyperbolic formulations of dispersive equations in continuum mechanics. (Talk)

- **NUMHYP 2021 - Trento, Italy (International conference):**
  A hyperbolic augmented model for the Nonlinear Schrödinger equation. (Talk)
- **Waves in One World Seminar 2020 - Edinburgh, Scotland (Online Seminar):**
  First Order hyperbolic equations approximating the Defocusing Nonlinear Schrödinger equation. (Talk)
- **IUSTI Student Seminar 2020 - Marseille, France (Seminar):**
  A hyperbolic augmented model for the Nonlinear Schrödinger equation. (Talk)
- **CEMRACS 2019 - Marseille, France (Workshop):**
  Stability theory for finite-difference schemes using modified equations. (Talk)
- **CEMRACS 2019 - Marseille, France (Workshop):**
  Augmented Lagrangian approach for the defocusing non-linear Schrödinger equation. (Talk)
- **SHARK-FV 2019 - Minho, Portugal (International conference):**
  A hyperbolic augmented model for thin film flows. (Talk, Poster)
- **SHARK-FV 2018 - Minho, Portugal (International conference):**
  Extended Lagrangian approach for the defocusing non-linear Schrödinger equation. (Talk)

SOFTWARE SKILLS

- **Programming languages:** Fortran 90, Python, Matlab.
- **Parallel programming:** MPI, OpenMP.
- **Queuing systems:** PBS.
- **User interface developing:** Qt.
- **Numerical Simulation:** COMSOL, ANSYS-Fluent.
- **Formal computation:** Wolfram Mathematica, Maple.
- **Operating Systems:** Linux, Windows, MacOS.
- **Editing:** LaTeX, Gnuplot, Paraview, Inkscape, Ms Office.

LANGUAGES

- Arabic: Mother tongue
- French - English: Fluent.
- Spanish - Italian: Advanced.
- Russian - German: Notions.

PUBLICATIONS

1. F. Dhaouadi, M. Dumbser, and S. Gavrilyuk. "A first-order hyperbolic reformulation of the Cahn-Hilliard equation". In: *arXiv preprint arXiv:2408.03862* (2024) Preprint

2. L. Río-Martín, F. Dhaouadi, and M. Dumbser. "An Exactly Curl-Free Finite-Volume/Finite-Difference Scheme for a Hyperbolic Compressible Isentropic Two-Phase Model". In: *Journal of Scientific Computing* 102.1 (2025), p. 13 Journal Preprint
3. F. Dhaouadi and S. Gavrilyuk. "An Eulerian hyperbolic model for heat transfer derived via Hamilton's principle: analytical and numerical study". In: *Proceedings of the Royal Society A* 480.2283 (2024), p. 20230440 Journal Preprint
4. F. Dhaouadi and M. Dumbser. "A structure-preserving finite volume scheme for a hyperbolic reformulation of the Navier–Stokes–Korteweg equations". In: *Mathematics* 11.4 (2023), p. 876 Journal
5. F. Dhaouadi and M. Dumbser. "A first order hyperbolic reformulation of the Navier-Stokes-Korteweg system based on the GPR model and an augmented Lagrangian approach". In: *Journal of Computational Physics* 470 (2022), p. 111544 Journal
6. F. Dhaouadi, S. Gavrilyuk, and J.-P. Vila. "Hyperbolic relaxation models for thin films down an inclined plane". In: *Applied Mathematics and Computation* 433 (2022), p. 127378 Journal
7. F. Dhaouadi, E. Duval, S. Tkachenko, and J.-P. Vila. "Stability theory for some scalar finite difference schemes: validity of the modified equations approach". In: *ESAIM: Proceedings and Surveys* 70 (2021), pp. 124–136 Journal Preprint
8. F. Dhaouadi, N. Favrie, and S. Gavrilyuk. "Extended Lagrangian approach for the defocusing nonlinear Schrödinger equation". In: *Studies in Applied Mathematics* 142.3 (2019), pp. 336–358 Journal Preprint

PhD Thesis

F. Dhaouadi. "An augmented Lagrangian approach for Euler-Korteweg type equations". PhD thesis. Université Paul Sabatier-Toulouse III, 2020
Thesis available Preprint