

# Fayssal Benkhaldoun

Outstanding Class Professor (Classe Exceptionnelle II) — Applied Mathematics

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## Short profile

Fayssal Benkhaldoun is an Outstanding Class Professor (Classe Exceptionnelle II) in Applied Mathematics at Université Sorbonne Paris Nord (USPN), and a senior member of the LAGA laboratory (UMR7539). His research focuses on computational engineering and scientific computing, with a strong emphasis on robust finite-volume methods (including characteristics-based approaches), hyperbolic systems, dynamic mesh adaptivity (2D/3D), and applications to combustion, shallow-water and morphodynamic models, plasma streamer propagation, and non-Newtonian flows (slurry and Bingham-type models).

He has developed a sustained and internationally recognized research activity, resulting in a substantial body of scientific publications and extensive doctoral and postdoctoral supervision. He regularly serves as reviewer and evaluator for numerous international journals and scientific institutions.

He conceived and organized the first International Symposium on Finite Volumes for Complex Applications (FVCA) in 1996, with the tenth edition (FVCA X) held in Strasbourg in 2023.

In parallel with his scientific work, he has held major academic and institutional responsibilities, including former Head of the Modelling and Scientific Computing team at LAGA, leadership roles within the IUT of Villetaneuse, and the development and coordination of international and joint degree programs.

## Academic positions and milestones

- PhD (INRIA Sophia Antipolis), 1988.
- Lecturer (Maître de conférences), INSA Rouen, from 1989 (promoted to 1st class in 1994).
- Habilitation (HDR), University of Rouen, 1998.
- Full Professor, University Paris 13 / USPN (IUT of Villetaneuse), since 2000 (1st class in 2010; Classe Exceptionnelle in 2018), specialized in modelling and numerical simulation.
- Multiple invited professor positions abroad (e.g., Kaiserslautern, Duisburg, CTU Prague, EMI & MINES Rabat, UM6P Benguerir).

## Research themes (recent focus)

Over the last years, the research has been structured around three main lines:

1. **Non-Newtonian flows and rheology-driven PDE models** (slurry, Bingham-type viscoplasticity).
2. **Efficient numerical methods for complex systems** (robustness, speed, and scalability).
3. **Numerical analysis of finite volume schemes** (stability/accuracy, well-balanced properties, interface states, etc.).

## Selected scientific breakthroughs (narrative)

Below is a structured narrative of major contributions that have shaped the scientific trajectory (representative, non-exhaustive):

- **Mesh geometry and scheme quality (1988).** Early identification of the critical influence of triangle angles in unstructured meshes on the quality of numerical schemes (thermo-diffusive flame propagation model).
- **Dynamic mesh adaptivity and Borghi's triple-flame conjecture (1994–2003).** Development of a dynamic mesh refinement strategy enabling decisive numerical evidence related to Roland Borghi's conjecture on the existence of triple flames.
- **Exact solution to a shallow-water Riemann problem with a bottom step (2001).** Proposal of an exact solution for a dam-break type benchmark over discontinuous bottom topography, providing a reference test for well-balanced / robust solvers.
- **Two-step finite volume schemes without Riemann solvers (2002–2010).** Introduction and evolution of a family of two-step schemes (SRNH) for hyperbolic-type problems without standard Riemann solvers; later evolution toward a Finite Volume Characteristics (FVC) approach where interface states are computed by the method of characteristics, yielding strong accuracy/speed gains compared to Roe-type schemes.
- **3D branching in streamer propagation (2014).** Extension of the dynamic adaptivity strategy to 3D unstructured grids, enabling (within a PhD framework) one of the first full 3D numerical simulations of branching phenomena in streamer propagation.
- **Non-Newtonian slurry and Bingham advances (2023).** Proposal of a new rheological model for phosphate slurry flows (with integration efforts in OpenFOAM through PhD work), and development of a regularized Bingham framework enabling existence and uniqueness results via convergence arguments.

## Industrial partnerships and funded projects (representative)

**Industrial contracts with IRSN (TOUGH2-MP, HPC, pre/post-processing, algorithmic geometry).** As PI, several consecutive industrial contracts were carried out with IRSN, including:

- Contract 1: 35 kEUR, 18 months (Jul 2013–Dec 2014): supervision of a postdoc (Minh Hoang Le).
- Contract 2: 45 kEUR, 38 months (Dec 2014–Feb 2018): continuation of the postdoc (M. H. Le) and supervision of a PhD (Tarek Ghoudi).
- Contract 3: 95 kEUR, 36 months (Mar 2017–Sep 2018): supervision of a postdoc (Imad Kissami) and a PhD (Ayoub Charhabil).
- Contract 4: 10 kEUR, 6 months (Jul 2018–Jan 2019): supervision of an internship on pre/post-processing methods for the massively parallel code TOUGH2-MP used at IRSN.
- Contract 5: 20 kEUR, 12 months (Nov 2019–Oct 2020): algorithmic geometry work on TOUGH2-MP in collaboration with an IRSN research engineer.

## International programs and institutional development

- **UM6P (Morocco), 2017–2019:** Associate professor; structured the Department of Complex Systems and Human Systems Engineering; launched research programs and coordinated the creation of a Bachelor in Data Science, a Master in Data Science, and a Master in Advanced Hybrid Modeling and Scientific Computing (initial and executive education).

- **Joint degrees and international training engineering (USPN / IUT Villetaneuse):** contributions to several double-degree projects and international programs (e.g., joint degrees with Vietnamese institutions; “En France” program for an annual cohort from Iowa State University; continuing exchanges with Canadian CEGEPs and engineering schools for student mobility).
- **International mobility and agreements:** active role in developing and operationalizing international internships/stage mobility, including a specific agreement with ETS Montreal (within the ADIUT–ETS national framework) and a strong record of internship mobilities.

## Major academic responsibilities and service

- **Former head of the Modelling and Scientific Computing (MCS) team, LAGA (2015–2020):** team leadership (approx. 30 members; budget management).
- **International relations:** in charge of international relations at the IUT of Villetaneuse; elected member at institutional councils; permanent invited member of the institute direction council; active member of restricted councils and working groups (including cross-department coordination initiatives).
- **Program leadership (IUT):** Director of studies for several programs: Professional Bachelor LP (2017–2021), DUT2 RT (2021–2022), and BUT2/BUT3 RT apprenticeship track (since Sep 2023), including initiatives for pedagogical international mobility supported by OPCO mechanisms.
- **National and institutional service:** multiple mandates within university governance and committees (selection committees/expert committees in Section 26, among others).

## Conferences, scientific events, and community building

- **FVCA symposium series:** Initiator and co-organizer of the Finite Volumes for Complex Applications (FVCA) international symposium series (FVCA I, 1996; FVCA II, 1999; FVCA IX, 2020; FVCA X, 2023; and other editions within the series).
- **Scientific schools:** Co-organization of thematic schools (e.g., Winter School on Complex Systems; UM6P spring school CAISAM on complexity analysis of industrial systems and advanced modeling).

## Teaching (selected, recent years + breadth)

Teaching spans from undergraduate to doctoral levels, in France and internationally (engineering schools, Master/DEA programs). Recent teaching activities include (selected examples):

- **Finite volumes** (including distance teaching in joint Master’s programs).
- **Signal analysis and Fourier analysis** (BUT RT tracks).
- **Cryptography (introductory)** (Professional Bachelor / apprenticeship and initial tracks).
- **Mathematics for digital systems and transmissions** (BUT1 RT).
- **Mathematics refresher course** (DU Networks program, 2022–2023, 30 hours).

In addition, yearly supervision of capstone projects for both engineering students (MACS track at USPN) and IUT students, including project-based work on programming (Python/PHP) and data processing when relevant.

## Supervision, evaluation, and editorial activities

- **Supervision:** more than twenty PhD/HDR theses supervised; more than one hundred Master’s and engineering projects.
- **Jury and evaluation:** chair of several PhD thesis juries (examples include works on a posteriori error estimation for coupled PDE systems; Darcy coupling with time-dependent convection–diffusion–reaction; integral formulations in electromagnetism and interface perturbation for Stokes systems).
- **Peer review:** reviewer for numerous international journals (e.g., JCP, IJNMF, Computers & Fluids, CMAME, etc.).

## Impact indicators (Google Scholar snapshot)

- **Total citations:** 1874 (*recent 5-year citations:* 583)
- **h-index:** 22 (*recent 5-year h-index:* 12)
- **i10-index:** 46 (*recent 5-year i10-index:* 18)

These indicators support a sustained methodological impact, with strong recent activity (5-year window) reflecting continued citation dynamics and relevance of foundational contributions as well as newer lines in non-Newtonian modeling and hybrid approaches.

## Selected publications (10)

1. Homogeneous incompressible Bingham viscoplastic as a limit of bi-viscosity fluids, A. Aberqi, W. Aboussi, F. Benkhaldoun, J. Bennouna, A. Bradji (2023).
  2. A new rheological model for phosphate slurry flows, Z. Ghoudi, S. Maazioui, F. Benkhaldoun, N. Hajjaji (2023).
  3. A Full 3-D dynamically adaptive unstructured grid finite-volume approach to simulate multiple branching in streamer propagation, F. Benkhaldoun et al. (2014).
  4. A simple finite volume method for the shallow water equations, F. Benkhaldoun, M. Seaid (2010).
  5. A sign matrix based scheme for non-homogeneous PDE’s with an analysis of the convergence stagnation phenomenon, S. Sahmim, F. Benkhaldoun, F. Alcrudo (2007).
  6. A Numerical Study of “unspherical” Ignition of a Droplet, I. Elmahi, F. Benkhaldoun, R. Borghi, S. Raghay (2003).
  7. Analysis and validation of a new finite volume scheme for nonhomogeneous systems, F. Benkhaldoun (2002).
  8. Exact solutions to the Riemann problem of the shallow water equations with a bottom step, F. Alcrudo, F. Benkhaldoun (2001).
  9. A nine points finite volume computation of droplet flame ignition, F. Benkhaldoun, R. Borghi, M. Gonzalez (1994).
  10. Numerical analysis of the two-dimensional thermo-diffusive model for flame propagation, F. Benkhaldoun, B. Larroturou (1988).
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